

The AMSAT[®] Journal

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Visit AMSAT-France's WWW Page

Take time to visit AMSAT-France's recently established WWW homepage at http://ourworld.compuserve.com/homepages/amsat_f. Included is an overview of their Maselle microsat project. (via F6BVP)



During a visit to JARL Headquarters in Tokyo, AMSAT-NA President Bill Tynan, W3XO and Executive Vice President, Keith Baker, KB1SF, toured the command station for both FO-20 and the new JAS-2 satellite. Bill and Keith are shown seated at the JAS-2 command consoles. Immediately behind Bill is Mr. Fugio Yamashita, JS1UKR, Director of JARL's Technical Laboratory and Mr. Tak Okamoto, JA2PKI, JAMSAT President. (JARL photo)

AMSAT-NA Representatives Attend JAMSAT Meeting

Bill Tynan, W3XO AMSAT-NA President and Keith Baker, KB1SF Executive Vice President, journeyed to Japan the week of March 12 to represent AMSAT-NA and the International Phase 3D Project at the JAMSAT Annual Meeting held in the city of Kyoto on March 16 and 17, 1996. They presented a joint talk on Phase 3D and its status to the assembled group, which was translated into Japanese by JAMSAT's President Tak Okamoto, JA2PKI. In turn, Hiroyuki Ohata, JM3MAJ presented an update on JAMSAT's SCOPE camera project (see related article and photos on page 4) due to fly on Phase 3D.

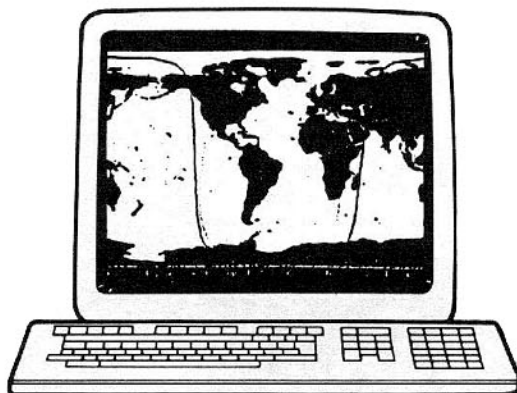
While in Japan, W3XO and KB1SF also met with officials of the Japan Amateur Radio League (JARL) and the Japanese Amateur Radio Industries Association (JAIA), providing both groups with information on Phase 3D's capabilities and status. Both Keith and Bill expressed their appreciation for the fine treatment they received from JAMSAT members. On return, they said that they considered it a very successful and most pleasant trip. (via AMSAT News Service)■

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and efforts to produce *The AMSAT Journal*.

Apogee View

By Bill Tynan W3XO

Life Members

Apogee View for the January/February issue of this Journal discussed the situation which prevails with respect to our Life Members. The fact is that since many became Life Members, postal rates, printing and paper have risen significantly. The editorial emphasized that we recognize that AMSAT has a commitment to continue to serve its Life Members, and that we have no intention of breaking that commitment. However, it went on to say that there are probably some number of Life Members who are no longer interested in amateur satellites and, thus, sending the Journal to them is a waste of money to the organization and may even represent a nuisance to them and their families. It also made the point that there are certainly some number of Life Members who are no longer living and therefore should be dropped from our rolls. It further stated that a letter would soon be sent to all Life Members asking them to tell us if they are still interested in amateur satellites and thus want to continue receiving the Journal. If so, would they care to make a contribution of one half of the regular dues to defray the cost of producing and sending them the Journal. The intent of the letter was to make it clear that this request for financial assistance was just that - a request, not a command. There was no intention to embarrass anyone who didn't feel inclined to make such a contribution.

Despite the careful wording of the letter, a few wrote questioning the wisdom and propriety of AMSAT sending such a letter. First, let me say that the idea is not new with AMSAT. I hold life membership in several organizations, including the IEEE, from which I have received similar letters. I did not feel pressured by these letters and my response was entirely voluntary. I would have hoped that AMSAT Life Members would have felt the same way. I am sure that most did. But a small number seemed to think that we were pressuring them. A few questioned our fiscal management, saying that we should have invested the money received from Life Members such that it would increase with inflation and still yield a sum sufficient to maintain the Life Members. Of course, that was, and is, the intention. However, it has always been the feeling of those who our members have chosen to set policy for our organization, that AMSAT is primarily a builder of Amateur Radio satellites, not a publishing house. If this is not what the membership wants, your Board Members need to know that. Now,

with Board elections coming up, is a good time to inform the existing Board members of your desires, and/or to nominate new ones who will better follow your wishes.

But, back to the money accumulated through Life Memberships. Back in the late 70s or early 80s the Board made a decision that we must continue to build satellites and that if doing so meant using some of our Life Member reserve funds, then that's what had to be done. A similar situation has occurred more recently with respect to funding Phase 3D. Despite the successes we and others have had in raising money for the Project, our organization has had to expend about \$180,000 more than it has taken in so far, if we were to keep up with our commitments. This has significantly depleted what was considered Life Member reserves and correspondingly reduced the income received from the investments they represented. As President and a member of the Board, I supported this approach. And, the other Board members did so also. I, and the other Board members, feel that we made a major commitment when we agreed to participate in the Phase 3D Project and that we must do everything we can to be sure that we hold up our end of the bargain.

If anyone felt pressured by the Life Member letter, I apologize. To those who responded, making contributions, thank you very much. To those who responded saying that AMSAT has a commitment to continue to service them as long as they are on this earth, without any further financial support on their part, I say that I fully agree with them. We will continue to serve them. To those family members who told us of a deceased former member, we extend our condolences and hope that AMSAT membership provided some cheer to their loved-ones during their final years. We thank you for informing us of the deaths of these former Life Members.

Quite a few have not responded as of the time this is written. Since the letter stated that we must hear by May 1, or we will assume that that Life Member is no longer interested in AMSAT or is deceased. Thus, this will be the last Journal sent to those people. If you did not respond but do wish to continue receiving the Journal, please let us know. We will be happy to reinstate you to full Life Membership. Be sure you PRINT your name and include your callsign. Those who handled the responses were not able to read a very few of them.

Continued on page 31

Phase 3D SCOPE News

Kasai Shigekazu, JG2BVO
JAMSAT Director, jg2bvo@amsat.org

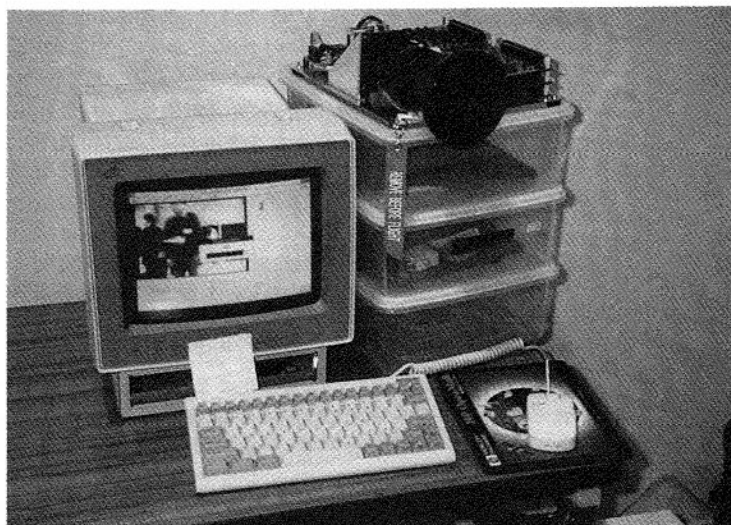
Phase 3D's *Spacecraft Camera Experiment for Observation of Planets and Earth* (SCOPE) has two high resolution 3-CCD (Charge Coupled Device) image sensors that provide wide and zoom lenses for snapping views of the Earth. Since 1990, when JAMSAT began participating in the Phase 3D project, many members have volunteered time and efforts to the SCOPE project. Here is the latest information of our SCOPE project along with an announcement on the availability of several photo images.

Figure 1 shows SCOPE which is a microprocessor based digital camera that connects with Phase 3D through its CAN-BUS LAN system. Moreover, SCOPE has an interface with RUDUK-U as a backup system. A CPU controlled feature achieves a more flexible and programmable system and independent operation. The SCOPE project team expects to change and improve its command software after the Phase 3D launch. Also, some commands may be released to Radio Amateurs for use as their farthest remote controlled camera in space. Radio Amateurs will be able to control SCOPE and obtain images via packet radio.

Current Status

Presently all electrical evaluations and fittings for Phase 3D SCOPE have been completed. In addition, construction on three flight modules (one will be for launch and the other two will be for

testing and backup) will have been completed by April 1996. These modules will be sent to the Phase 3D Orlando Flight Integration Facility in Orlando, Florida for testing prior to launch.



A working engineering prototype of JAMSAT's SCOPE camera currently slated to fly later this year on Phase 3D, was set up and demonstrated at the recent annual meeting of JAMSAT held on March 16th and 17th in Kyoto, Japan. (AMSAT-NA photo by Keith Baker, KB1SF)



PacComm has the most options for 9600 bps satellite work.
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The following .jpg graphic files are available via the AMSAT home page (<http://www.amsat.org>) and provide a visual overview of the Phase 3D SCOPE Project:

- SCOPE01.JPG: The SCOPE Evaluation Model (EM) was a hardware breadboard for discussing electrical design, debugging on-board software and determining its optical parameters.
- SCOPE02.JPG: Assembling SCOPE Engineering Model. This module was used for evaluating the layout of SCOPE's components including two lenses and PCBs. This module allowed us to determine SCOPE's weight and dimensions.
- SCOPE03.JPG: EM Iino Kazuhisa, JH1QQN carefully assembles SCOPE housekeeping unit. Also, JH1QQN's excellent soldering work greatly helped to construct SCOPE.
- SCOPE05.JPG: SCOPE kits. Aluminum panels painted in black and will be used as a frame of SCOPE's flight model. To avoid contamination, they are wrapped in polyethylene bags that are typically used for freezing foods in a refrigerator!
- SCOPE06.JPG: SCOPE PCB and the lens
- SCOPE07.JPG, SCOPE08.JPG: Assembling SCOPE
- SCOPE09.JPG: Assembling SCOPE's PCB on the housekeeping unit. Oohata Hiroyuki, JM3MAJ (right) is involved in SCOPE electrical design.
- SCOPE10.JPG: Front view. SCOPE uses two cameras which have a 3-CCD image sensor as its eyes. Wide and zoom lenses are readied to take pictures from various altitudes of the orbit. Ordinarily, zoom lenses are used with fixed focus. However, no zoom mechanics are required in space.
- SCOPE11.JPG: Optical discussion. Yamanaka Jun'ichi, JA1KUD adjusts optical balance and exposure.
- SCOPE12.JPG: Camera hoods. Many hoods are examined as sunlight will sometimes affect images. Much time was spent properly determining the locations of the eye opening in consideration of Phase 3D's antennas.
- SCOPE13.JPG, SCOPE14.JPG: Examining hoods and installing them on SCOPE.
- SCOPE15.JPG, SCOPE16.JPG, SCOPE17.JPG, SCOPE18.JPG, SCOPE19.JPG: Mounted lenses and hoods are fixed on SCOPE with small bolts. Other components, all frames, PCBs, and cameras are held with metal bolts. These bolts make a low resistance contact between all metal components to discharge harmful electrical charges derived from cosmic rays. There are more than 100 bolts used on SCOPE. Although the frames were painted black, the bolts will be carefully examined for good electrical contact.
- SCOPE20.JPG: SCOPE EM (upper right) and SCOPE EM (bottom)
- SCOPE21.JPG, SCOPE22.JPG: Additional SCOPE Photographs. ■



Satellite enthusiasts attending this year's JAMSAT Annual Meeting, pause for a group photo at their conference site on the campus of Notre Dame Women's College in Kyoto, Japan. (Photo by Yoichi Sakurada, JP1NWZ of Japan's CQ Ham Radio magazine)



W3XO displays a model of FO-20 presented to AMSAT-NA by JARL officials during recent meetings in Tokyo with JARL Executive Director Masayoshi Ebisawa, JA1DM (second from left) and Fujio Yamashita, JS1UKR (far right). (photo by Mitsu Sugawara, JN1LQH, JARL)



As a part of AMSAT's ongoing efforts to provide equipment manufacturers with planning input for future products that will exploit Phase 3D's expected capabilities, W3XO and KB1SF met in Tokyo with officials from the Japan Amateur Radio Industry Association (JAIA). (JAIA Photo)

Estimated Ariane 4 Profile for Phase 3D

Ken Erlandes, N2WWD

Editor's Note: In the last issue of The AMSAT Journal, N2WWD provide an orbital estimation for the launch of Phase 3D on an Ariane 5. Since there is a possibility that Phase 3D may be launched on an Ariane 4, the following estimated Keplerian elements are provided for your information.

The following is my estimate for the Phase 3D orbital sequence should the spacecraft be launched on an Ariane 4 booster:

The injection orbit was modeled from the standard Ariane 4 GTO:

Perigee altitude = 200 km
Apogee altitude = 35,975 km
Inclination = 7 degrees
Argument of Perigee = 178 degrees
Longitude of Descending Node = 8 deg W

Since the time from launch to injection is unknown, Mission Elapsed Time (MET) is referenced to the injection time. The time-independent EFG state vector was estimated to be:

Vector format = 10107
Satellite Name: P3D A4
Catalog Number: 99934
Epoch MET: 0.00025952500
0/00:00:22.423 MET
EFG E: 6515.79540161128 km
F: -915.73532449250 km
G: 0.00000000000 km
Edot: 1.49712858330 km/s
Fdot: 9.56792270890 km/s
Gdot: -1.2478566913 km/s
ndot/2 (drag): 0.00000001454 rev/day²
nddt/6: 0.00000E+00 rev/day³
Bstar: 1.28735E-07 1/Earth Radii
Elset #: 1
Rev @ Epoch: 1.49503322922

Burn #1 occurs at an apogee, following orbital injection. This burn increases the perigee altitude to 500 km. The estimated Burn #1 parameters are as follows:

Burn #1

Intrack: 30.9 m/sec
Crosstrack: 0.0 m/sec
Radial: 0.0 m/sec

Burn #2 occurs at perigee, on a revolution subsequent to Burn #1. This burn increases the apogee altitude to the nominal Phase 3D value of 47,000 km. The estimated Burn #2 parameters are as follows:

Burn #2

Intrack: 146.5 m/sec
Crosstrack: 0.0 m/sec

Radial: 0.0 m/sec

Burn #3 occurs at apogee, on a revolution subsequent to Burn #2. This burn raises the perigee altitude to the nominal Phase 3D value of 4,000 km. This burn simultaneously increases the orbital inclination from 7 degrees to the nominal Phase 3D value of 60 degrees. The estimated Burn #3 parameters are as follows:

Burn #3

Intrack: -367.9 m/sec
Crosstrack: 1246.6 m/sec
Radial: 114.7 m/sec

Sample Keplerian elements were estimated for an injection time on 15-SEP-96/12:00UTC. Since the actual burn times are impossible to predict due to constraints on the spacecraft, the first physical event times (Burn #1 = 000/05:17:31.095 MET, Burn #2 = 000/10:38:19.925 MET, Burn #3 = 000/18:09:46.748 MET) were used for visualization purposes. The estimated Keplerian elements are:

GTO Injection:

Satellite: P3D A4
Catalog number: 99934
Epoch time: 96259.50025953
Element set: 1
Inclination: 6.9982 deg
RA of node: 346.8202 deg
Eccentricity: 0.7313899
Arg of perigee: 178.0065 deg
Mean anomaly: 0.2120 deg
Mean motion: 2.26492092 rev/day
Decay rate: 1.45400e-08 rev/day²
Epoch rev: 1

Post Burn #1:

Satellite: P3D A4
Catalog number: 99934
Epoch time: 96259.72049878
Element set: 2
Inclination: 6.9983 deg
RA of node: 346.7292 deg
Eccentricity: 0.7208307
Arg of perigee: 178.1879 deg
Mean anomaly: 179.7875 deg
Mean motion: 2.24425526 rev/day
Decay rate: 1.45400e-08 rev/day²
Epoch rev: 1

Post Burn #2:

Satellite: P3D A4
Catalog number: 99934
Epoch time: 96259.94328617
Element set: 3
Inclination: 6.9984 deg
RA of node: 346.6448 deg
Eccentricity: 0.7717327

Arg of perigee: 178.2540 deg
Mean anomaly: 359.8521 deg
Mean motion: 1.65933485 rev/day
Decay rate: 1.45400e-08 rev/day²
Epoch rev: 2

Post Burn #3:

Satellite: P3D A4
Epoch time: 96260.25679106

Catalog number: 99934
Element set: 4
Inclination: 59.9968 deg
RA of node: 346.4301 deg
Eccentricity: 0.6740242
Arg of perigee: 180.0725 deg
Mean anomaly: 179.7634 deg
Mean motion: 1.52667827 rev/day
Decay rate: 1.45400e-08 rev/day²
Epoch rev: 2 ■

1996 AMSAT Field Day Competition

Andy MacAllister, WA5ZIB

Field Day is once again just around the corner beginning at 1800 UTC on June 22nd for a 24-hour period. We are proud to announce the 1996 AMSAT Field Day Competition. It is open to all Amateur Radio operators. U.S. and Canadian amateurs are to exchange ARRL section and Field Day transmitter class. Foreign amateurs should exchange country name and signal reports. The AMSAT competition is to encourage the use of all amateur satellites, both analog and digital. This year CW contacts and digital contacts are worth three points as outlined below. Here are the rules for the 1996 AMSAT Field Day competition.

1. Analog Transponders

- Each satellite transponder is considered a separate band. This means that AO-13 Mode "S" is separate from AO-13 Mode "B".
- All phone QSO's and all CW QSO's on a given satellite transponder are considered separate bands. This means that AO-13 Mode "S" CW is separate from AO-13 Mode "S" phone.
- Therefore, for reporting purposes, AO-13 has *four possible bands* including Mode "B" CW, Mode "B" phone, mode "S" CW and Mode "S" phone. On the reporting sheet under the *Satellite/Mode* heading show the satellite name and transponder mode. Example: AO-13/B.
- Columns are provided for tabulation of CW and phone contacts.
- All packet/RTTY/ASCII/AMTOR QSO's through analog transponders are counted as CW QSO's.
- Phone QSO's count for one point and CW QSO's count for three points.
- Cross-mode (CW-phone) contacts are not allowed.
- The use of more than one transmitter at the same time on a single satellite transponder is prohibited. This means that two stations at the same Field Day site can operate through AO-13 at the same time, but only if one is operating Mode "S" and the other Mode "B". If two stations at a given site are set up for Mode "B" operation, only one can be on AO-13 (CW or phone). The other station can be used for different hamsats (like AO-10) or other Field Day activities.

2. Digital Transponders

- For the Pacsats (LO-19, KO-23, etc.) each satellite is considered a separate band.
- Do not post "CQ" messages. Simply upload *one* greeting message to each satellite and download as many greeting messages as possible from each satellite. The *subject* of the uploaded file should be posted as *Field Day Greetings* addressed to *ALL*. The purpose of this portion of the competition is to demonstrate digi-

tal satellite communications to other Field Day participants and observers.

- The following uploads/downloads each count as a three point digital contact: (a) Upload of a Satellite Field Day Greetings file (one per satellite). (b) Download of Satellite Field Day Greetings files posted by other stations. Other non-Field Day files are not to be counted for the event.
- Satellite digipeat QSO's do not count for any score and the use of gateway stations to uplink/downlink is not allowed. The MIR PBBS is not to be used for Field Day operations.
- If FO-20 is active, the JA transponder can be used for analog CW and phone activities under the analog transponder rules, and the JD system can be used as a separate transponder under the digital rules.
- Sample Satellite Field Day Greetings File: *Greetings from N5EM Field Day Satellite station near Galveston, Texas with 24 participating members in the AMSAT-Houston group. All the best and 73!* Note that the message stated the call and name of the group, where they were located and how many were in attendance.

3. Operating Class

- Stations operating portable and using emergency power (as per ARRL Field Day rules) are in a separate operating class from those at home connected to commercial power. On the report form simply check off *Emergency* or *Commercial* for the Power Source and be sure to specify your ARRL operating class (2A, 1C, etc.).

The Satellite Summary Sheet (see page 19) should be used for submittal of the AMSAT Field Day competition results to Andy MacAllister WA5ZIB, Vice President User Services, 14714 Knights Way Drive, Houston, TX 77083-5640. Deadline for submissions is August 1, 1995.

Competition was tough in 1995 and should be even tougher in 1996. The station submitting the highest score for portable operation using emergency power will receive a plaque at the AMSAT General Meeting and Space Symposium in Tucson, Arizona in November.

We hope this event provides satellite operators with the practice necessary to set up a ground station and effectively operate via the satellites in an emergency situation. Remember that Field Day also provides a good opportunity to expose newcomers to the amateur-radio satellites. Most of all, it should be a lot of fun for all who participate. **GL ON FD ES 73** ■

The FodTrack Realtime Tracking System

by Manfred Mornhinweg, XQ2FOD

mmornhin@eso.org

Putting together a good automatic groundstation for digital satellites is not a simple task. Receiver noise figure, radio modifications, choosing among digital or analog modem technologies, and software are all important items. But keeping the antennas pointed at the satellites, and keeping the radio tuned are two of the most important tasks if an automatic station is to work with reasonable efficiency.

How it started

When I began working with the digital satellites two years ago, I began with an easy setup, in order to get some experience with digital satellites before starting to complicate matters. I set up a simple omnidirectional antenna, so I would not have to worry about tracking, and built a hardware AFC circuit into my transceiver. For each pass, a small program would send the approximate initial frequencies to the transceiver, and from then on the AFC would keep it tuned during a pass of an FSK satellite, or the PSK modem would adjust tuning via *mic-clicks* for PSK satellites. I used PB/PG for the communication software, and WA2N's SatSked for the scheduling. All this ran in a window of the DESQview/X multitasking program, which also ran an F6FBB packet BBS in another window.

This simple approach worked quite well, but there was a very annoying problem with the PSK satellites as PSK signals have several sidebands, and the modem locks in as easily on a sideband as on the correct signal. So on many passes the modem kept the

receiver locked on a sideband for an entire pass and no data were acquired. Spurious signals posed another problem for both types of satellites. On many occasions, between the time when the initial frequency was set and the satellite appeared, a spurious signal would pull the receiver away from the correct frequency. So quite often my station lost whole passes. Also, I soon wanted to put up a directional antenna system, to improve my station's efficiency; the omnis do allow operation, but on the FSK satellites it is important to be able to get data for most of every pass in order to keep the directory updated and get selected files.

So I started to look for a good tracking system. I considered the TrackBox, but I did not like paying for an external computer, while my PC had still some processing power to spare. I also considered several trackers that do the calculations in the PC, and use an internal or external interface to communicate with the radio and the rotator. However all of these systems rely on TSR programs which are difficult to manage in a multitasking environment: If you load them *before* the multitasker, you lose too much memory, and if you load them *inside* the multitasker, there are problems with the clock! This occurs because the TSR programs cannot access DOS functions, so they have no easy access to the computer clock. This forces programmers to use the PC's "clockticks" to keep track of time. But inside a multitasker, not all clockticks are available! So the internal timekeeping of TSR programs in a multitasker gets out of step, and the tracking runs way too slow.

It seemed to make no sense to buy a second PC to do the tracking, or to separate the BBS from the satellite station. So I tried for two months to write a TSR program that would interact with InstantTrack to keep its clock running at the correct speed inside DESQview, but alas, I'm not a professional programmer, and only succeeded in hanging up my PC a few hundred times...

After getting tired of this, and ever more in need for a usable tracker, I finally took the solemn decision to roll my own. The new program would have to run in foreground, stand alone or inside DESQview, Windows, or another multitasker; it should be able to receive commands from a scheduler like SatSked, it should read the computer clock, read a standard Keplerian data file, generate its own satellite position data, and control a rotator and a radio through the PC's ports, using only simple and low-cost interface hardware. As my PC had all its "normal" serial and parallel ports used, the program would have to be compatible with nonstandard ports. The rotator control loop should be closed *in hardware*, so that a computer lockup or a software bug (they *do* happen!) could not damage the rotator by sending it against its end stop. I also wanted the program to implement *antenna flipping*, to avoid losing pass time on passes that would otherwise

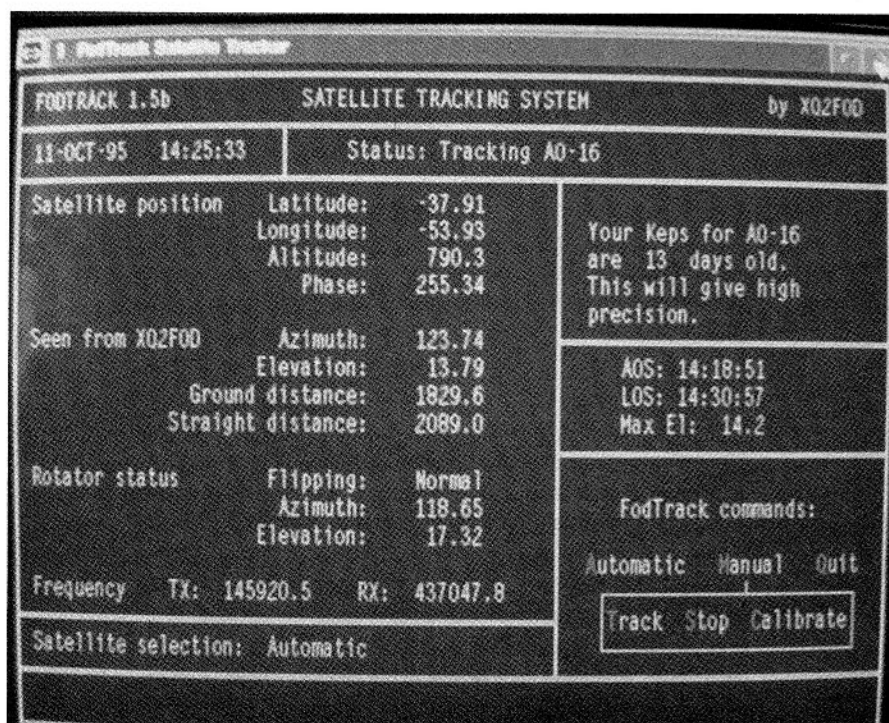


Figure 1. FodTrack screen during an AO-16 pass.

need the antenna turning over a full circle in the midst of the pass to avoid reaching the rotator end stop. The idea for FodTrack was born!

FodTrack's Evolution

The first task was to find a usable set of equations to get a satellite's position starting from Keplerian data. I finally found this in *The Satellite Experimenter's Handbook*, written by Martin Davidoff, K2UBC, and published by the ARRL. After a week of evening programming, and sorting out a few pitfalls, I had a routine that could reliably calculate the position of a satellite at any given instant, and this routine became the heart of my new program. The rest was easy to add, and soon I had a very crude program that would output two 7-bit values representing azimuth and elevation every second to the parallel port. After designing and building a simple interface, I could finally control my newly acquired rotator!

Two months later I added a user interface to the program, called it version 1.0, and released it to the public domain. The package contained the program, documentation, a schematic for the interface, and accessory files. Many stations downloaded it, and started making suggestions for improvement. Some of them reported bugs! A month later I released version 1.1, which increased the output resolution to 8 bits, fixed several minor bugs and improved several things. During the New Year's night I sat at my station, watching the screen to see if my sidereal time calculation was right. It was!

Version 1.2 followed in March '95, and version 1.3 in April. Version 1.3 was the first one to have Doppler tracking too, even if for the moment it was usable only on the Yaesu FT736, because I had no access to other radios. But soon several stations offered to beta-test FodTrack on their radios, so I could include tested support for the Kenwood TS790 and several Icom radios in version 1.4, released in July. The next month version 1.5 was ready, with step-tracking, antenna parking, AOS-LOS display, and several cosmetic improvements. Version 1.5b (not released), adds support for dual monoband Icom radios. Version 1.6, will also have configurable colors, will be released as soon as I find the time to finish it... My intention is to continue to support and develop FodTrack, as far as my time permits, accommodating all reasonable suggestions for improvement. If someday I get tired of this, I will make the source code widely available, so that others can continue developing it.

Is it for you?

FodTrack will control a Yaesu/Kenpro G-5400/5600 rotator, and a Yaesu FT736, Kenwood TS790, or several models of Icom radios. The interface can easily be adapted for other rotators, and support for other radios may be included on request.

FodTrack is ideally suited to run in a fully automatic station for the digital satellites, which uses a single PC with multitasking software to handle everything. FodTrack has been tested under DESQview 386, DESQview/X, Windows 3.1,

Windows 3.11 and Windows 95. You can also use FodTrack on a stand alone PC, but that does not make full use of it's capabilities. To automate a station with FodTrack, the scheduling program needs to send commands to FodTrack at the start and the end of each pass. That is much easier to do if everything runs on a single PC.

If you want to run on a single PC and you have some reason not to use a multitasker, then you cannot use FodTrack.

I am using FodTrack in a DESQview/X window, while in another window I run SatSked together with NZ3F's SatLink and WA0PTV's Gateway Node, complete with all auxiliary programs. A third window runs an F6FBB BBS for terrestrial packet. Additionally, I can open more windows to run other tasks like a word processor to write this article. And also there is a G8BPQ packet node and a fax receiving program running on my PC; it's a quite busy machine!

Many stations are using FodTrack together with Windows and WISP. Chris, CN8HB, has provided a program called FOD-INIT which acts like glue between FodTrack and Windows/WISP.

FodTrack can also be used to steer the antennas for analog satellites, but the Doppler correction feature makes little sense in this case. For this reason, on analog satellites FodTrack simply displays a Doppler correction value in parts per million, and does not control the radio.

If you are willing to build your own interface, then FodTrack is about the cheapest way to go. The rotator interface uses just 5 chips and a few discrete components. The radio interface can be built from one transistor, one resistor and one diode! And the program is free. I guess this feature will appeal to many of you!



Figure 2. This is how XQ2FOD's PC screen looks during normal operation. The upper window runs the satellite scheduling and communication (SatSked, SatLink, and Gateway Node). The lower window runs FodTrack. Behind them is a third window with the packet BBS. (F6FBB photo)

Setting it up

The FodTrack package comes with a sample configuration file, called FODTRACK.CFG. You must edit this file, to put in your callsign, latitude and longitude, the addresses of the ports you want to use, the type of your radio, and several other parameters. You need a parallel port for the rotator interface, and a serial port for the radio interface. Any ports can be used, at any addresses, so feel free to add ports to your PC! You don't even need any IRQs for the ports used by FodTrack, because they are used for output only. The configuration file contains enough explanations to allow you to set it up without confusion, or at least so I hope!

FODTRACK.FRC is a file for frequencies and modes for the satellites you want to track. The receiving frequency for the PSK satellites is quite critical, since it must reflect the frequency errors of the satellite and your radio. You will probably have to fine-tune it once the system is running. You may also fine-tune the other frequencies, but those are much less critical.

It might be a good idea to get a fresh Keplerian data file, as the one provided with FodTrack may be quite old. Generally it is acceptable to have Keplerian data up to two months old, but with wide lobed antennas and FSK satellites, 4 months may still be OK.

You may start the program without having the interfaces attached, but of course things get much more exciting when the interfaces are available! By the way, you can use any standard RS232 to TTL converter to control your radio, but the rotator interface is specific to FodTrack.

Once started, the program will permit you to command it manually to track satellites. Whenever the selected satellite is in view, FodTrack will be sending position data to the rotator, and frequency data to the radio. But if you switch FodTrack into automatic mode, nothing will happen, the program will just idle along. You need to set up the commands from your scheduler first!

Automatic mode in FodTrack means nothing more than this: FodTrack reads a command file once every second, and tracks whatever satellite that file specifies. If the file says *none*, FodTrack will idle. So before the start of a pass your scheduler must write a command file with the name of the satellite to be tracked, and after the pass it writes a command file with the contents *none*.

I suggest you do this in the following way:

- In each satellite's directory, create a file named FODTRACK.CMD, containing the name of the satellite. Use upper case letters and spell the name exactly as it appears in the Keplerian data file (*KO-23* is OK, *ko-23*, *KO23* and *ko23* are not).
- In the batch file that executes at the start of a pass, after the sentence where it switches to the satellite's directory, add a sentence to copy the FODTRACK.CMD file into your FodTrack directory. For example,
- COPY FODTRACK.CMD C:\SAT\FODTRACK\FODTRACK.CMD
- If you use SatSked, these files are named KO-23.BAT, etc.
- In the FodTrack directory, create a file named FODTRACK.STP containing the word *NONE*.
- In a batch file that executes at the end of each pass (SSCLEAN.BAT if you use SatSked) add the sentences:
- CD C:\SAT\FODTRACK
- COPY FODTRACK.STP FODTRACK.CMD

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Now, if you run FodTrack in automatic mode, whenever SatSked starts a pass, FodTrack will track the selected satellite, and whenever the pass ends, FodTrack will return to idle.

For WISP, the procedure is quite similar. You can make the batch files and then call them from WISP's event scheduling system. I have never tried this myself, but many stations are doing it that way. Another possibility is to use CN8HB's FOD-INIT.

Fine tuning

When you connect the rotator for the first time, you should go through the calibration procedure. The basic idea is to adjust the output voltage potentiometer on the back of the rotator control box, so that when FodTrack drives the rotators to full scale, they *actually* move to the full scale position! It's as easy as that!

If you work PSK satellites, you will find it necessary to fine-tune the RX frequency. Do the following:

- Run a pass under manual control (pulling the plug of the radio interface is enough to do this...).
- Near the start or near the end of a pass (to reduce the error caused by clock/Keplerian imprecisions) note the difference between the frequency displayed by FodTrack, and the one you have to tune your radio to in order to get proper demodulation.
- Modify the frequency in the FODTRACK.FRC file to account for the difference.

In order to get accurate tracking, you need an accurate computer clock! If your PC is more than 2 or 3 seconds off time, you will see considerable detuning when a PSK satellite is high up in the sky. At low elevations, and for FSK satellites, the allowable tolerance is greater, but if you have your clock a minute off, the satellites may hide outside your antenna's beamwidth!

Many PC clocks are not very accurate, and often the DOS clock runs far away from the hardware clock! WA2N's SatSked has some extremely useful functions to keep a PC's clock straight. Even with the poor clock on my new motherboard, I can keep running for two or three weeks before having to correct the time, thanks to SatSked. An even better way is to connect a GPS receiver to the PC, or have the computer call a dial-up time service once a day.

Where to get FodTrack

The complete package, which contains the program, documentation, auxiliary files, and schematics for the rotator interface and several different radio interfaces, can be downloaded via Internet from the amsat.org FTP server, or from ftp.funet.fi. Every time I

release a new version, I upload it on one of the digital satellites. I address those files to FODTRK. If you include this address in your select equation files, then you will get the updates automatically.

If you don't want to build your own interfaces, you can get them ready made from AMSAT-CE. The rotator interface bundled with the interface for Yaesu radios, is available for a contribution of about \$110 (US), which goes towards our CESAR-1 project, a 9600 baud pacsat. A diskette with the latest release of the software is also included. The interfaces are also available separately. If you are interested in this, please contact Carlos Godoy, CE2HI, via any of these ways:

- Mail : AMSAT-CE
- P. O. Box 803, Viña del Mar, Chile
- Fax : +56 32 884073
- e-mail: ce2hi@itata.disca.utfsm.cl

Feedback

I would be glad to hear from you. If you have any questions, bug reports, improvement suggestions, or just want to say that FodTrack is terrible or superb, feel free to contact me:

- Satellites: XQ2FOD @ AO-16, UO-22, KO-23, KO-25
- Packet : XQ2FOD@XQ2FOD.SER.CHL.SA
- e-mail : mmornhin@eso.org (be patient, I have access there only every second week...)
- Fax: +56 51 214314
- Mail: P. O. Box 381, Coquimbo, Chile

And if you have written some software that could be useful to other hams, make it available! ■

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Satellite Antennas Hints and Kinks

By Howard Sodja W6SHP

w6shp@amsat.org

Editors Note: This article originally was presented at a Project OSCAR seminar in September 1990. The following has been updated and appeared in the February 1996 issue of the AMSAT-UK OSCAR News.

Years of home brewing plus many ideas gleaned from reading AMSAT-NA, AMSAT-UK and ARRL publications (1) have taught me how to build my projects better. Here are some tips that may be of help with the most important part of an amateur radio satellite station, the antenna system.

Low Cost Satellite Antennas

Some antennas can be constructed from discarded items. I once made a two meter $5/8$ wave ground plane for mode A and T from a broken off car radio antenna I found lying in the street and four wire clothes hangers and a few odds and ends in my junk box. Figure 1 shows the simple matching network I used. A similar ground plane for use on VHF or UHF can be made from a coax chassis connector and number 12 or larger wire scraps. Solder the vertical element to the center conductor and attach the radials with nuts and bolts to the four corners, then solder each corner. Make the vertical element a bit longer than calculated and bend the radials down 25 to 30 degrees a short distance from the connector flange. Then trim the vertical element (in small increments) for the minimum SWR at the low end of the band in which it will be used. When the SWR begins to go back up, it should be lowest near the center of the band. If not, trim carefully until it is. Then little by little bend the radials down until you get a 1 to 1 SWR. This will be between 30 to 45 degrees (Figure 2).

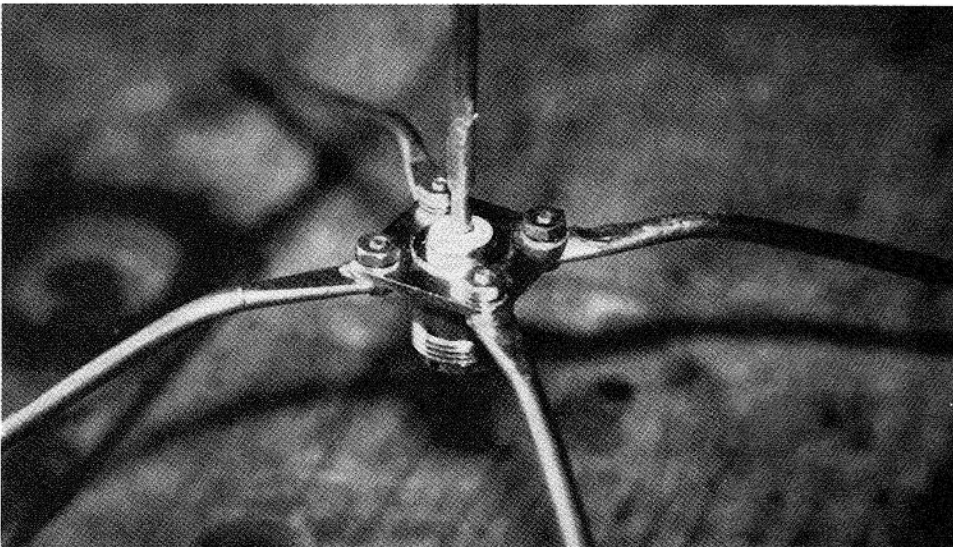


Figure 2. Number 8 wire was used for a 70cm $1/4$ wave groundplane. Ends were hammered flat, filed to shape and drilled. A small propane torch, used carefully so as not to overheat the connector, made the soldering easy. Flux paste on the connector's flange aided solder bonding. The vertical element's end was filed down until it fit inside the center pin connector. Waterproof the coax connector so water cannot seep into your coax.

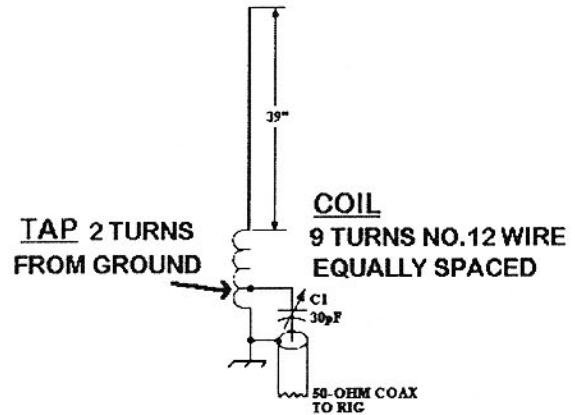


Figure 1. Circuit diagram of a $1/4$ wave groundplane antenna. C1 is a 3- to 30-pF trimmer. (From *The ARRL Handbook for Radio Amateurs*, ARRL, 1976, pg. 329)

Discarded corroded ham beams are another excellent source of recyclable antenna materials. I salvaged an old phased pair of inoperative Cushcraft two meter beams that were covered with corrosion and rust and were destined for the trash dump. To salvage the usable materials, I first removed the surface rust and corrosion with a wire brush. Then I soaked all the hardware with WD-40 (a penetrating oil) overnight. After disassembling all of the aluminum elements from the boom, I soaked everything in an acid bath. (Acid solutions made specially for cleaning aluminum are available in well stocked hardware stores.) After further brushing and sanding

out the corrosion pits with fine wet sandpaper, the elements and boom were as good as new!

I then drilled pilot holes on one boom 90 degrees and about an inch (2.5 cm) from the existing element holes. I increased the pilot holes to the diameter of the elements and secured the elements with new sheet metal screws one size larger than the original size (so these new screws were tight in the old holes). For the price of an acid bath and a few stainless steel nuts, bolts and sheet metal screws, I had a new two meter crossed Yagi (Figure 3). When carrying out this sort of reconstruction it is important to use good stainless steel hardware for structural connections. Brass hardware can be used for electrical connections where there will not be much mechanical stress. The extra expense will be paid back with interest in a few years when antenna maintenance is needed.

I recycled a friend's ancient Hy-Gain trap tri-bander in a similar fashion. After removing the corroded and rusted hardware and traps and giving the elements a good acid bath, brushing and sanding, I had the makings (for free) for either a 15 or 10 meter beam for modes A, K or T. Essential rusted steel parts, like the boom to element brackets, were wire brushed and painted. Since mode A was my objective, this beam came back to life as a full size three element 10 meter beam.

After years of trying various products and techniques to eliminate rust once it is well established, I have found a way that really works. First wire brush the metal with a wire brush wheel attached to either your bench grinder (the best way) or power drill until it is shiny. A base coat of Rust-Oleum™ Rusty Metal Primer (7769), then a coat of Clean Metal Primer (7773) and two coats of Aluminum Metallic Finish (7715) will keep your paint from blistering and the rust from reappearing for many years. Be sure to use Rust-Oleum thinner as needed to keep the paint at the proper viscosity so it brushes or sprays on properly.

Antenna wire left over from an 80 meter dipole project became the element for my 10 meter horizontal delta loop, which keeps my mode A downlink strong on the overhead portion of my mode A passes. By hanging it only 15 feet (4.5 meters) high with the feed-point near my shack's window I was able to feed it with a short scrap of coax left over from a 50 foot roll I bought for another antenna project. A quarter wave transformer section of 75 ohm RG-59/U coax from the delta loop's feed point to my 50 ohm coax feedline provided a simple match (2).

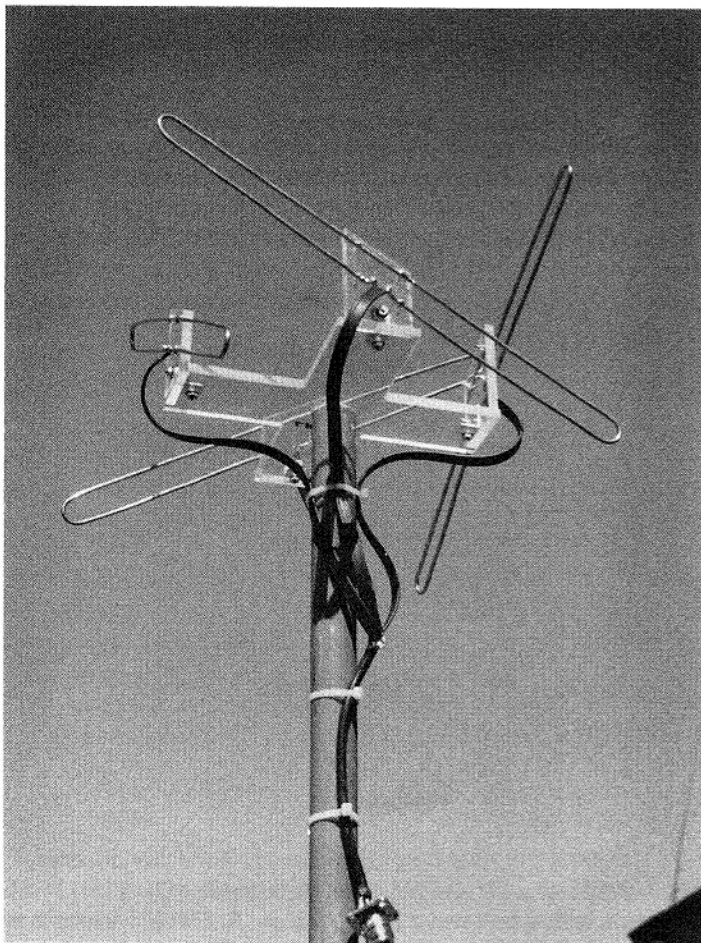


Figure 4. 70cm Lindenblad antenna.

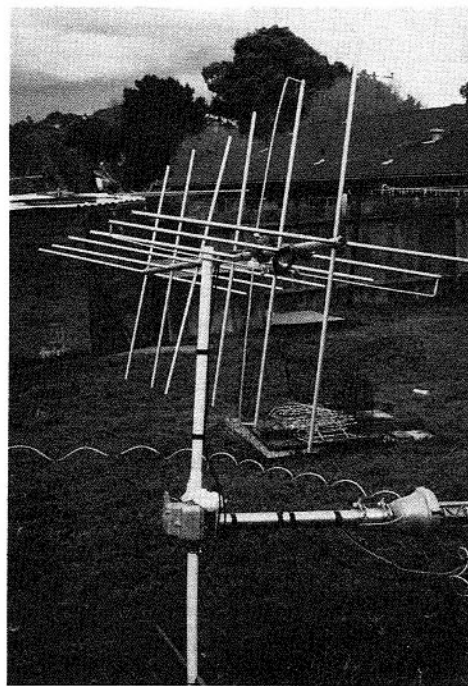


Figure 3 . Reconstructed two-meter crossed Yagi antenna.

The 70cm Lindenblad antennas I described in *The AMSAT Journal* and *OSCAR News* articles (3) were built totally from scrap plastic and wire I already had. They were mounted on a pair of old broom handles that I knew I'd have a use for some day (Figure 4). This is the best omnidirectional antenna I have ever used since the ability to switch polarizations minimizes QSB and maximizes signal strength.

Antenna Matching

I have had good luck with folded dipole driven elements as they are easy to design and match and have a *flatter* SWR curve than dipoles (Figure 5). Besides checking your SWR, check your power output from your matching network, as a bad matching network may give you a good SWR while dissipating RF as heat. I discovered an antenna feedpoint toroid balun that had a power loss I found unacceptable, so I replaced it with one of the lower loss balancing method discussed in the ARRL's Antenna Handbook².

Circularly polarized antennas capable of being switched from right to left handed circular polarization will give you the best performance, as polarization can change during a pass. Figure 6 shows how to do this with 52 ohm antenna feed points. If you use folded dipole driven elements you can modify figure 6 for a 300 ohm feedpoint impedance by using the cabling as shown, but replace the quarter wave of 75 ohm coax from the coaxial T connectors to the dipoles with a convenient length of RG-62/U (93 ohms) or RG-133/U (95 ohms) coax. The half wave coaxial balun in Figure 7 will give you a 4:1 impedance step up so you will have a good match to a folded dipole feedpoint. Although it is not necessary, purists can tweak the folded dipole's spacing until the SWR meter's needle does not move off the peg.

When ever you make a coax balun always make it a bit longer than the calculated length. Do not forget to include the coax velocity

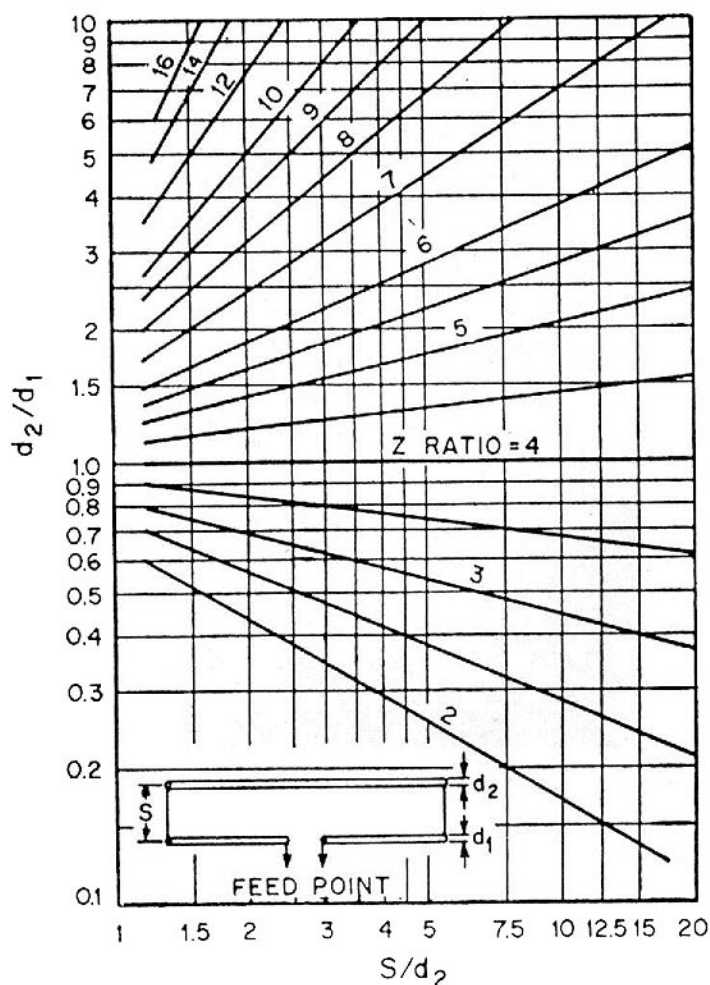


Figure 5. Impedance step-up ratio for the folded dipole, as a function of conductor diameters and spacing. Dimensions d_1 , d_2 and S are shown in the inset drawing. The step-up ratio, r , may also be determined by calculating: $r = \{1 + [(\log \times 2S/d_1) / (\log \times 2S/d_2)]^2\}$ (From *ARRL Handbook for Radio Amateurs*)

Figure 6. Switchable polarization antenna system complete with cable specifications. When calculating lengths of individual cables, be sure to include the properly velocity factor of cable used. For 400 ohm folded dipoles replace the two $1/4\lambda$ 75 ohm lines from coaxial T connector to the antenna with a convenient length of 93 ohm (RG-62/U) or 95 ohm (RG133/U) coax that are equal in length. See Figure 7 for dipole matching section.

$$\frac{1}{2}\lambda = (5905)(VF)/\text{FREQ}$$

- λ in inches
- VF = velocity of coax
- Frequency in MHz

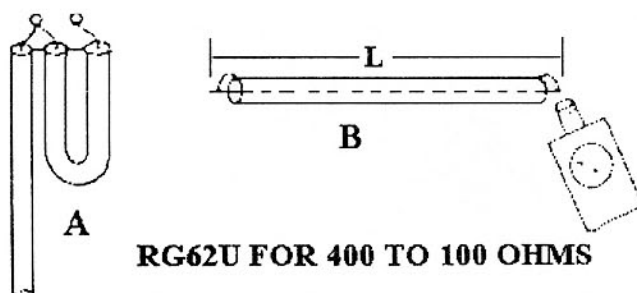


Figure 7. Conversion from unbalanced coax to a balanced load can be done with a half-wave coaxial balun, A. Electrical length of the looped section should be checked with a dip-meter, with ends shorted, B (RG62/U for 400 to 100 ohms). The half-wave balun gives a 4:1 impedance step-up. (From *ARRL Handbook for Radio Amateurs*, 1976, pg. 625.)

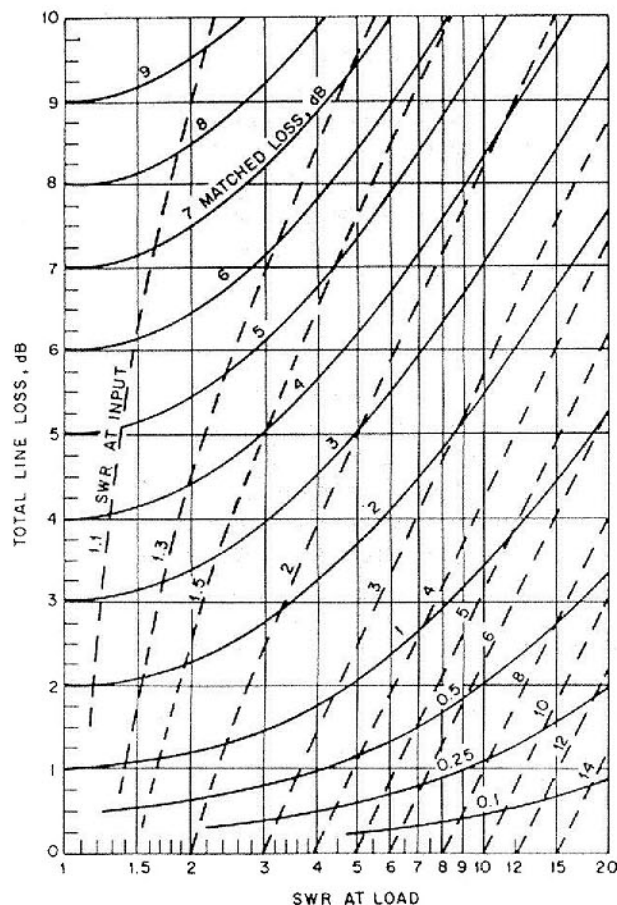


Figure 8. Matched-line attenuation loss in dB to the total line loss and to SWR values at the line input and load. The horizontal at the bottom of the graph represents 0 dB of matched-line loss. (From *The ARRL Antenna Book*.)

factor in your calculations. Use a dip-meter to determine its resonant frequency, trimming it until it is tuned to the center of your band of operation, as shown in Figure 7. I have made several coax baluns and the actual electrical length has never been exactly what the calculations said it should have been. My low SWRs always confirms the dip-meter length was right.

SWR Measurements

The antenna should be as close as possible to where it will be permanently installed when you tune for the minimum SWR. A low SWR on a tall step ladder in your back yard (so you can tune it easily and have the SWR sensor attached to the antenna's coax feedpoint) may be fine for a rough cut tune after assembly. But it may need to be retuned again when in place on its mast or tower. It is usually not practical to get at your antenna's feed point once it is permanently raised and mounted. But how can you compare an SWR taken with the sensor on the antenna's feed point with an SWR when the sensor is connected to your antenna at the far end of a long run of coax? The chart in Figure 8 does this job nicely.

Coax Loss

How do you know for sure what your total line loss is for this chart? Use a coax attenuation chart? No way! You should test and log (in your station's log book) the loss of every coax section between your rig and antenna at the highest frequency where it will

- | | | |
|----|---|---|
| 1 | Pipe, Copper
3" dia. 5" long | Cut ends square.
Drill or punch for
connectors 3-3/4"
from bottom. |
| 2 | Pipe, Copper
3/4" dia. 4" long | Solder to center
of 10 |
| 3 | Disc, Copper
3/4" dia.
1/16" — 1/8" thick | Drill thru center.
Solder solid hook
up wire between
disc and connector
to space disc
3/16" from pc 2. |
| 4 | Disc, Copper
3/4" dia.
1/16" — 1/8" thick | Drill thru center.
Solder solid hook
up wire between
disc and connector
to space disc
3/16" from pc 2. |
| 5 | Connector, Coax | BNC, SMA or N
type. Solder to
prevent turning.
For large
connector use
chassis punch |
| 6 | Connector, Coax | BNC, SMA or N
type. Solder to
prevent turning.
For large
connector use
chassis punch. |
| 7 | Nut, Brass
1/4"—20 hex | |
| 8 | Nut, Brass
1/4"—20 hex | |
| 9 | P/C Board,
double sided.
Top 4" x 4". | Drill hole in center
to clear 1/4-20 bolt
Solder 7 and 8
each side of hole.
(Use bolt 11 to
hold nuts in place
when soldering.) |
| 10 | P/C Board,
double sided.
Bottom 4" x 4". | Solder 2 in center. |
| 11 | Bolt, Brass
1/4-20 x 3 1/2" | Insert thru 12
then thru 7 and 8. |
| 12 | Locking Nut,
Brass
1/4-20 Hex | To hold piece 11
after resonance
adjustment. |

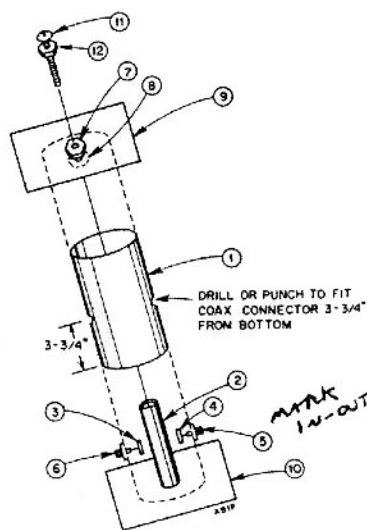


Figure 9. Instructions for constructing a mode J desense filter.

be used. Test even those short 1 or 2 foot (30 to 60 cm) coax interconnection jumpers, and add them all together to get your actual total line loss.

Test each section with your SWR/power sensor first on the transmitter end, note your SWR (it should be 1:1) and your power in. Then put your sensor on the dummy load end. Note your power out and calculate your dB loss for each section. If you have never done this you may be in for some surprises. This is what convinced me to convert all of my 2 meter and higher coax lines to *N* connectors.

Don't forget to test accessories used in line with your coax. A local ham told me he found his brand new *N* connector coax switch had almost 6 dB of loss. I bought a new *PL-259-to-N* adaptor that I discovered had a similar loss.

Beware of cable marked RG-8/U TYPE (and other RG-* TYPE coax) as this means it does not comply to the specs for RG-8/U (or other RG-* specs) as far as loss and velocity factors. I bought some RG-8/U TYPE coax from a well known *cheap electronics* chain store that had unacceptable impedance bumps (detected as a high SWR) at splice points (those periodic bulges in the coax). Also the *good* sections had higher losses than shown in coax attenuation charts.

This same store sells cheap coax connectors that have higher impedance bumps (SWR) and losses than my Amphenol connectors. And when I tried to solder groundplane radials to this store's coax chassis connector, the center pin insulation melted and fell out of the metal case. Quality coax connectors now use Teflon insulation which has low loss at high frequencies and has a high melting temperature. So beware of *cheap* coax and connectors. You usually get what you pay for.

Some quality *RG-8/U TYPE* coax may be better than the specs, such as the coax Belden and other quality coax manufacturers produce. These companies publish their specs so you can compare them with the standard *mil-spec* coax. Take your handitalkie, SWR/wattmeter, dummy load and coax connector adapters with you when you go surplus shopping to see if that used coax or accessory is still good before you buy it.

The hassle of making special balanced dummy loads (to test baluns and matching sections) and taking the time to test all your coax sections and in-line accessories will pay for itself if you discover problems like those I discussed. In satellite work, every dB counts. Also, by adding up your total feed system loss and doing some simple calculations with your antenna gain figures you will be able to figure what your true EIRP is.

More practically, it will be a snap to trouble shoot any signal strength loss in the future. You will know what signal loss is normal.

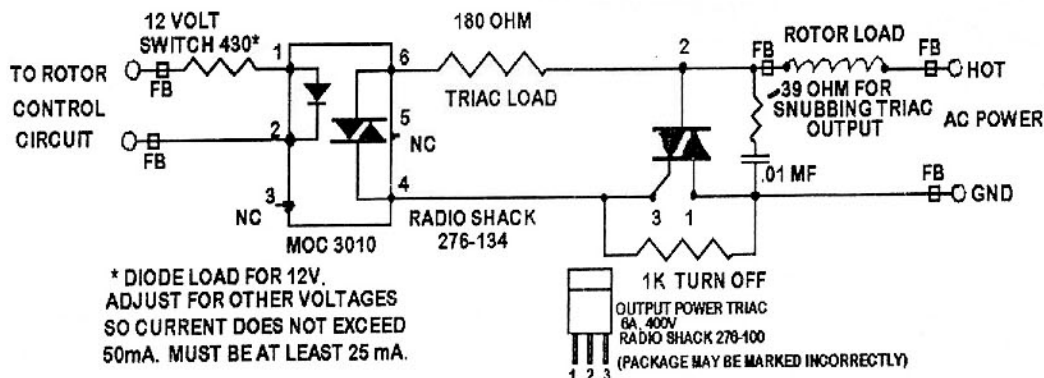
When you suspect your line loss has increased, measure the loss from your receiver to some convenient mid point, like where the coax leaves your room. If that loss is as expected, you know your trouble is between that point and the antenna. Repeat this *divide and conquer* search by testing the loss between the room entry and some mid point, like a preamp, and you will quickly locate the lossy component. Also you will know when it is time to change your coax by its increased loss, not its age.

9913 Coax

As the name of the game with satellite transmission lines is low loss, I have become fond of Belden's 9913 coax. Sure, hardline is better, but 9913 is easier. Once you pick up a few tricks and skills you will agree that installing *N* connectors on 9913 is much easier (and less lossy) than using the standard so-called *UHF* PL-259 connectors. To make a successful *N* coax connector fitting you must:

- use the proper type connector with an oversized center pin (like Amphenol's 82-202-1006),
- use vinyl plastic electrical tape (3 to 5 inches, 7.5 to 13 cm) wrapped around the coax end up against the *N* connector's shield clamp ring to provide a snug slip fit when assembled,

AUTO-TRACKING TRIAC ROTOR CONTROL



NOTE: MOUNT INSIDE ROTOR CONTROL BOX PARALLEL TO MANUAL SWITCHES. I RECOMMEND AN INPUT LED AND OUTPUT LED (WITH DIODE RECTIFIER) SO YOU BUILD ON PERF. BOARD TO ASSURE NO GROUND COMMON TO INPUT DC AND OUTPUT AC. BUILD AND TEST CAREFULLY AS LETHAL VOLTAGES MAY BE ENCOUNTERED.

W6SHP. DATA FROM MOTOROLA REF.

Figure 10. W6SHP Auto-Tracking TRIAC Rotator Control.

- take your time and carefully make all cuts to a 1/64 inch (.4 mm) tolerance or better, then double check your dimensions when done,
- use a small tube cutter so your cuts are all perfectly square and clean, leaving the shield unnicked, by ever so slowly tightening the roller blade as you cut (so you can stop just before you touch the shield),
- take your time fanning and trimming the shield so it lies evenly and smoothly over the entire clamp surface, but not beyond it to where it will interfere with assembly. No strands should cross.

Cut your coax a few inches longer than you need so you will feel free to cut off a fitting you are not happy with and try again until you get it right. Use what is referred to in ARRL publications as the *improved clamp* (like the Amphenol 82-202-1006) as it is easier to fabricate. Detailed fabrication illustrations with exact dimensions can be found in publications like *The ARRL Handbook*, *The ARRL Antenna Book* and *The ARRL Electronics Data Book*.

Stiff 9913 does not wear well where it must flex a lot, like where your coax leaves your boom up to your fixed attachment point on your mast or tower. Here a short run of RG-8/U will do better. If you already use 9913 for these flexing areas, you will eventually find kinks appearing at the points of most bending stress. This can be rectified by cutting 3 staggered lengths of RG-8/U that will go from the boom to beyond the kink. Secure them to the boom and the flexing 9913 with tape so they will take the bending stress and *round* the bend radius. Make these coax stiffeners long enough, with each piece at least an inch (2.5 cm) longer than the previous one so you are not soon faced with a new kink where the RG-8/U stiffener section ends.

My first circularly polarized beam had the coax routed forward along the antenna boom to the elevation rotator boom up to the mast, where I had a small flex section. It is claimed that your circular polarization pattern is better if the coax is not attached along the boom but instead hangs from the boom's rear end and loops forward to the main mast. I did it this way on my next two beams. But I found no noticeable difference in performance on the air (where it counts) between these two coax routes. This is probably because we rarely get a perfectly circularly polarized downlink signal. But I did notice more flexing problems with a long 9913 coax loop off the rear of the booms. A poorly made *N* connector may slip apart from the extra weight it must support on beams that have their coax connectors mounted 90 degrees to the beam's boom. Also, I can no longer track an overhead pass horizon to horizon by tracking 180 with the elevation rotator. I am now limited to 90 degrees elevation and must change the azimuth heading 180 degrees at mid pass.

Although *N* connectors are said to be waterproof, I still feel better wrapping the connectors with sealing tape, like Coax-Seal™

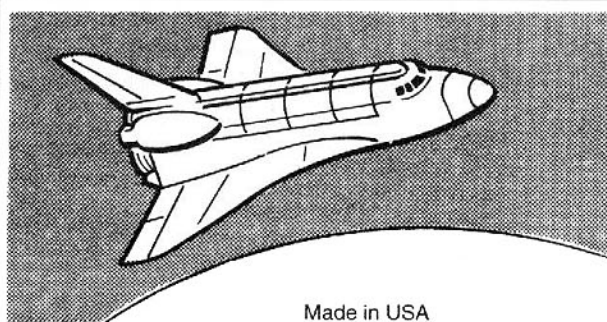
which you then can mold after wrapping to exactly the way you want. This moldable tape is great for any coax weatherproofing, such as coax balun ends or feed points. Use several layers so the surface cracking that will occur with age will not go all the way through to the coax and connector. Linerless rubber splicing tape made for electricians by Scotch 3M™ is better for coax fittings, as it will not crack with age and is not so messy to remove. The overlapping rubber splicing tape flows together as it cures to become a solid rubber covering that needs to be slit lengthwise and peeled off to remove. Silicone outgases corrosive vapors that hasten shield corrosive damage. This will shorten the lifetime of your coax connectors.

Secure your coax, rotator lines and control cables with self locking plastic *zip* ties that are made for outdoor use, and are UV resistant. They are usually black. The white ties commonly used are for indoor use only. They will eventually break on their own if used outdoors. I like to use these ties at the end of my tape wraps to keep the end of the tape from lifting up with age.

Computer QRM

Computer birdies can ruin your best low loss run from your beam. The more sensitive your system, the louder these birdies get. Check to be sure all your computer and TNC cables are shielded with the shields attached to ground. I bought a *bargain* computer cable that did not connect the DB connector's mechanical ground shell to the cable's shield. Place wide copper or aluminum tape over all cracks, openings and poor fitting shielding inserts on your

AMATEUR TELEVISION



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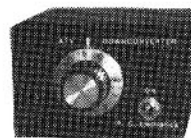
Many ATV repeaters and individuals are retransmitting Space Shuttle Video & Audio from their TVRO's tuned to Spacenet 2 transponder 9. Others may be retransmitting weather radar during significant storms or home camcorder video. If it is being done in your area on 420 MHz - check page 538 in the 95-96 ARRL Repeater Directory or call us, ATV repeaters are springing up all over - all you need is one of the TVC-4G ATV 420-450 MHz downconverters, add any TV set to ch 2, 3 or 4 and a 70 CM antenna (you can use your same 435 Oscar beam). We also have downconverters and antennas for the 902-928 & 1240-1300 MHz bands. In fact we are your one stop for all your ATV needs and info - antennas, transceivers, amps, etc.

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Full color & sound
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 antenna & 13.8 Vdc @ 1A

computer (like the metal strips for cable connectors on the rear of PC slot cards).

Most computers have a well vented and poorly grounded cabinet. Check out your cabinet and scrape the paint off all mating surfaces and under cabinet screw heads. Buy some copper screen and cut out pieces to go over all vent openings and the fan exhaust hole. Leave enough overlapping screen so you can easily mount the screen inside the cabinet. Run a solder bead along the screen's edges and reinforce ground attachment points where the screen can be screwed to existing cabinet screws. Add ground mount screws if you cannot secure the screen with existing cabinet screws.

After making a good ground system for your station, if you still have a problem with birdies, check everything connected to ground. Disconnect the ground straps one at a time to see if any ground connection will make your computer birdies decrease. I found one device that reduced my remaining birdies significantly when *disconnected* from my station's main ground strap bus. It was also connected to ground via coax connectors shields, so there must have been a ground loop radiating the birdies. These efforts have left me only two very faint computer birdies that are rarely encountered and easily covered by downlink signals when they are.

You should have EMI AC filters on your computer's and rig's AC outlet or line. If you still have problems with birdies, disconnect each cable and line one at a time to determine what line is radiating your birdie. Wrap the offending cable several times through a toroid core on the end where the birdie is being generated to choke off the RFI flowing on this line's shielding.

Mode J Desense Filter

Desense problems await most mode JD and JA users. Although a quarter wave shorted coax stub will null out the offending 2-meter uplink signal, its loss on the downlink signal is unacceptable to me. The cavity desense filter (Figure 9) does a better job with no noticeable attenuation of the downlink signal. Have the plumbing store where you buy the copper pipes cut them for you. Be sure to make it clear that you need a precisely sized pipe that is cut without excessive blade pressure that might flare in the pipe ends.

TRIAC Antenna Control

Automatic antenna tracking is great, but the clacking of the relays inside your rotator control box every time the beams move is annoying. The circuit in Figure 10 does this switching silently. I sent this circuit to Brooks (of Kansas City Tracker) and he said this is how he does it at his station. He said he does not suggest this in his manual out of concern for liability in case people build it incorrectly and electrocute themselves or fry their computer. So be careful if you make this circuit and test it carefully when you are done. A fault can be lethal to you or your computer. Do not build it if you are not familiar with standard electrical safety construction practice. *Consider yourself warned!*

Antenna Masts

A low cost self supporting 40 foot (12 meter) mast can be made from a common 50 foot (15 meter) telescoping guyed TV mast. This

is my double zepp antenna support mast, which I use for my 15 meter modes K and T uplink, as well as on all of the HF bands.

Extend each 10 foot (3 meter) section 5 feet (1.5 meter) and redrill the locking pin holes through both masts to secure them at half mast with a large stainless steel bolt, washer, lockwasher and nut. Mark a dark vertical line where the two masts telescope together so you can see how they should be positioned for the holes to line up. Then you will not have to hunt for the holes later when raising the masts. Use the circular clamp locking bolts that are at the top of each mast section to tighten out the slop between masts. You will end up with a self supporting 30 foot mast. I purchased two more 10 foot (3 meters) mast sections to similarly telescope into the top mast to extend my mast to 40 feet (12 meter).

For a base I dug a post hole and positioned a pipe vertically in the hole that just fit inside the bottom mast section. I filled the hole with concrete, leaving 4 inches (10 cm) of this pipe above the top. I secured the bottom mast section onto this pipe stub with a bolt similar to what I used for the upper sections. I fabricated a sturdy wooden frame and attached it to my house about 10 feet (3 meter) above the ground. The top of the first 10 foot (3 meter) mast section was securely clamped to this frame. This brace also provided a convenient point to tie my ladder while raising and lowering my antenna mast, giving me a safe and solid structure to work from.

This self supporting mast whipped (but did not break) more than I liked during a strong wind storm so I added a set of Mylar guys near the top to keep it (and my SWR) rock steady. But as guys are not needed normally, I can raise and lower it by myself for antenna maintenance. Stainless steel hose clamps secured to the top of each section will keep each section from going too far inside the lower section when lowered. This is a convenient place to secure your open line stand-offs.

Guy wires are often a problem, as metal ones need ugly egg insulators, and even then you may end up with an unexpected resonant section. Common synthetic ropes have a stretch problem. Fortunately Mylar rope has been designed specifically for antenna guying. When you use the proper size line, it is as strong as steel guy wire and its stretch, even on long runs, is negligible. The owners and staff of United States Rope (4) will be happy to discuss the specs of their Mylar guy rope with you. I used a set of Mylar guys for 10 years before I decided it was time to replace them. The sun's UV light eventually weakens them, but in my experience, not any faster than my galvanized guys rusted. United States Rope tested my 10 year old line and found that although it was getting weaker, it still met the service specs I needed, so it was not about to fail.

Locating Materials

Getting supplies for antenna and other home brew projects can be a challenge. Check your telephone book's *Yellow Pages* for local electronics surplus stores. Sometimes *general* surplus and salvage stores will have an electronics section, or materials that you can use. Check local universities and colleges as they often have public outlets where they dispose of their surplus electronic supplies and gear. Usually these sources are strictly *walk-in* warehouses where sales staff will not know all that they have. Just wander around and look at all the goodies not normally available by mail or regular electronic suppliers. Cannibalized cheap devices from these

sources and from ham flea markets are a good source for *junk box* stock.

Additional sources for components for building projects can be found by going through the ads of ARRL and AMSAT publications. AMSAT and ARRL advertisers deserve your support as they help make these publications available at prices we can easily afford.

Notes

1. For sources of satellite related construction publications, contact the following three organizations for a complete list of their handbooks and other literature:

ARRL

225 Main St.

Newington CT. 06111-1494

Telephone: 203-594-0200

The *ARRL Antenna Book* and *The Satellite Experimenters Handbook* are the two best sources I have found for both practical and theoretical antenna related information.

AMSAT-NA

850 Sligo Ave. Suite 600

Silver Springs MD. 20910-4703

301-589-6062

The AMSAT Journal reports both news and construction projects. This alone is worth the membership cost.

AMSAT-UK

94 Herongate Road

Wanstead Park

London E12 5EQ

England

Telephone: 0181-989-6741

AMSAT-UK *Oscar News*, their membership journal, also reprints AMSAT-DL, JAMSAT and other international AMSAT news and construction projects. It is well worth the membership cost.

2. *The ARRL Handbook, The ARRL Antenna Book and The Satellite Experimenter's Handbook*, published by the ARRL (1) all have theoretical overviews and practical construction details on this and related subjects.
3. *The AMSAT Journal*, Volume 13, No. 3, July 1990, published by AMSAT-NA and *Oscar News*, June 1991, published by AMSAT-UK (1).
4. Mylar guy line rope is available via:

U.S. Rope

711 Hamilton Ave

Menlo Park CA 94025

415-322-1881 ■

Satellite Summary Sheet - 1996

Analog Satellite Operation

Satellite/Mode	CW QSO's	Phone QSO's
Multiplier	x 3	x 1
Analog Subtotals		

Digital Satellite Operation

Satellite	Upload/Download
Multiplier	x 3
Digital Subtotal	

Score Calculation

Analog CW Subtotal (above)	
Analog Phone Subtotal (above)	
Digital Subtotal (above)	
GRAND TOTAL	

Your Field Day Callsign_____

Your Group Name _____

ARRL Field Day Classification _____ Section _____

Power Source: Emergency _____ Commercial _____

Your name and home call _____

Home address _____

Don't Forget to Send Your Field Day Summary Sheet by August 1st to Andy MacAllister, WA5ZIB, 14714 Knights Way Drive, Houston, TX 77083-5640. Also include any comments and photos for use in a Field Day summary article that will appear in *The AMSAT Journal*.

STS-74 SAREX

Lou McFadin, W5DID

w5did@amsat.org



Following the successful in-space docking of Russia's Mir Space Station and the Space Shuttle Atlantis, STS-74 and Mir-20 crew members pose for a group portrait aboard the Mir Space Station's Base Block. Wearing two-tone shirts are STS-74 crew members from the left Ken Cameron, KB5AWP, Jim Halsell, KC5RNI, Chris Hadfield, KC5RNJ/VA3OOG, Bill McArthur, KC5ACR, and Jerry Ross, N5SCW. The Mir-20 crew members are left to right, Sergei Avdeyev, Thomas Reiter, and Yuriy Gidzenko. (NASA photo)

As many as six Amateur Radio licensed astronauts at one time have been on some shuttle missions and as many as six licensed cosmonauts have simultaneously occupied the *Mir* space station. However, for a short period when the STS-67 shuttle mission overlapped the Mir 17 and Mir 18 missions a total of *twelve people were in space aboard three separate spacecraft* (*Endeavour*, Soyuz TM-21, and *Mir*) who were licensed to use Amateur Radio equipment. But the combined STS-74/Mir 20 mission that flew during November 12-20, 1995, marked the only time *eight licensed Hams have been aboard the same spacecraft*. The mission also marked the first time space travelers representing four different countries (Canada, Germany, Russia, and the United States) were aboard the same spacecraft.

The Mir 20 long term crew consisted of cosmonauts Yuri Gidzenko, ROMIR and Sergei Avdeev, U9MIR, and ESA astronaut Thomas Reiter, DP0MIR. The STS-74 shuttle crew consisted of Commander Ken Cameron, KB5AWP, Pilot Jim Halsell, KC5RNI, Jerry Ross, N5SCW, Bill McArthur, KC5ACR, and Chris Hadfield, KC5RNJ/VA3OOG.

Jerry Ross earned his Novice and Technician licenses while preparing for the STS-37 mission in April 1991. He notes that he has only used Amateur Radio from space, and never used it from the ground. STS-74 marked his fifth shuttle flight, and third SAREX flight.

Bill McArthur had earned his license while training for the STS-58 mission which flew in October 1993. He is an enthusiastic ham on the ground as well as

in space. During the two week STS-58 mission he made over 500 random QSOs.

Chris Hadfield asked the Canadian Space Agency (CSA) to help him obtain a Canadian call sign and asked for the suffix "OOG". He was assigned VA3OOG and surprised many hams around the world who did not know that he'd be using a Canadian callsign!

The Canadian Space Agency quickly picked up on Chris's license and decided to set up a ham shack at their new headquarters in Saint Hubert, Quebec. The station's call is VA2CSA and Chris will dedicate the facility. In an official statement the CSA said, "The link with Amateur Radio operators and DXers is part of a renewed effort to reach out to Canadians and others around the world to provide information about the significant aspects of the STS-74

mission and later missions by other Canadian Astronauts."

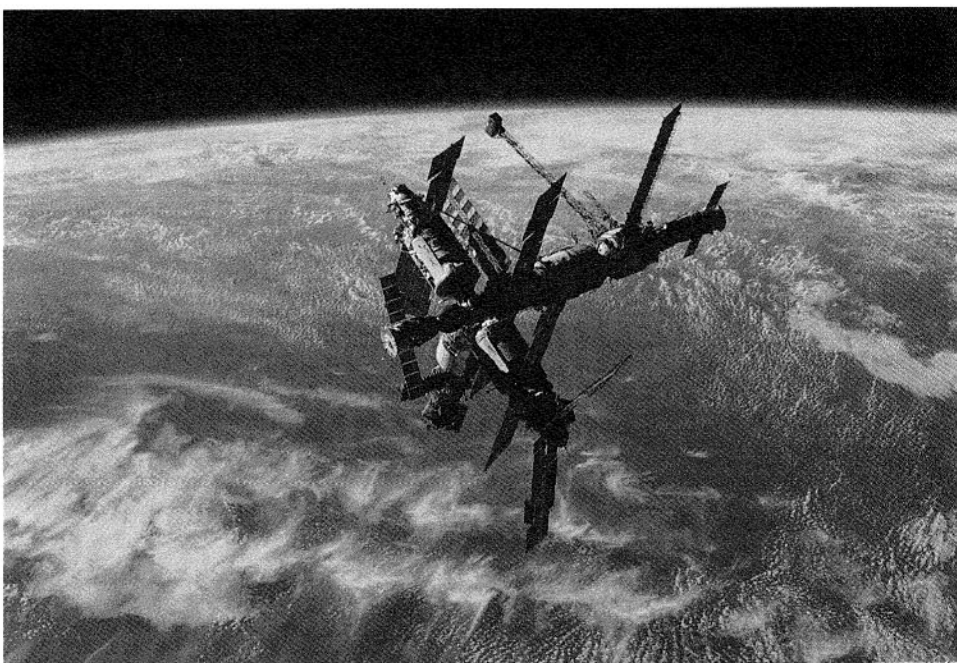
The other active Canadian Mission Specialist, Marc Garneau, is scheduled to fly on the STS-77 mission and is not a licensed ham. However Canadian payload specialist Robert Thirsk has been assigned Canadian license VA3CSA for the STS-78 Life and Microgravity Sciences (LMS) mission. STS-78, scheduled for launch in late June, is a SAREX flight and most of that crew have earned Amateur Radio licenses, including the backup payload specialists.

The key purpose for the STS-74 mission was a logistics flight for *Mir*. The primary payload in *Atlantis's* cargo bay was the 4087 kg. (9011 lb.) docking module, a stand-off for *Mir's* docking port. The docking module will make it easier for the future joint *Atlantis-Mir* missions. *Atlantis* also carried 470 kgs. (1037 lbs.) of dry cargo for *Mir*, including clothing, food, and experiments.

The German SAFEX-II (Space Amateur Funk Experiment) is an enhancement to *Mir's* amateur radio rig (see "The Amateur Radio Space Experiment SAFEX II" *The AMSAT Journal*, November/December 1995). Unfortunately it turned out that a couple of manuals were missing and about a dozen folks came up with the same solution simultaneously of *having the shuttle crew carry them to Mir*. It is not quite that easy, as SAFEX-II is flying as part of the European Space Agency's EUROMIR 95 mission. Therefore, the German SAFEX team had to ask ESA, which in turn asked the Phase I U.S.-Russian management team. Permission was received and the paperwork was signed as the manuals were being prepared for use on *Mir*.

Ken Cameron invited me to view the launch from the Kennedy Space Center's VIP site so several of the Phase 3D integration team members took the time off to visit the Cape. What Cameron did not know was that I was waiting for him as the crew walked out of the crew quarters building to board the bus which would take them to the launch pad. It was a pleasant way to surprise him.

Chris Hadfield also had an additional surprise waiting for him. Since his wife is not allowed to be at the crew walkout two



With the Earth's horizon providing the backdrop, Russia's *Mir* Space Station as seen from *Atlantis*, soon after the two spacecraft began their relative separation on November 18, 1995. (NASA photo)



Sergei Avdeyev, flight engineer for *Mir-20* logs data into a record at his berth in the crew quarters aboard *Mir*. (NASA)

of her friends showed up with a sign saying "Helene was here in spirit."

The first launch attempt on November 11th had to be scrubbed due to bad weather; not bad weather at the Cape, but bad weather at the emergency Transatlantic Abort Landing (TAL) sites in Spain and Africa. One day later on November 12th, the weather in Florida and across the

Atlantic cooperated, and STS-74 was launched at 7:31 am.

Mir's primary communications links are made through the Russian ground stations. While *Mir* has two relay satellites in geosynchronous orbit, they are not used as often as NASA uses its TDRS constellation. As a result, when *Mir* passed over the United States about an hour after



STS-74 astronauts and Mir-20 cosmonauts at work in Mir's Core Module. In the foreground is Yuriy Gidzenko (note two-meter transceiver communication microphone above Yuriy's right hand). (NASA photo)



Astronaut Chris Hatfield (left), Mir-20 Mission Commander Yuriy Gidzenko (center) and Sergei Avdeyev, Flight Engineer (right) share a unique view through windows on the aft flight deck of Atlantis. (NASA photo)

Atlantis' launch and Thomas Reiter was on *Mir's* 145.550 MHz rig inquiring about the status of the STS-74 launch.

Officially SAREX contacts were not supposed to occur until after the shuttle docked with *Mir*. However this crew was particularly enthusiastic, and used the radio whenever they got the chance. Within seven hours after liftoff, they were making general QSOs.

Each SAREX mission includes a check pass where a ground station makes contact with the shuttle to evaluate the hardware's performance. For *Mir* related missions, the check pass takes on added importance since the same VHF radio used for Amateur Radio operations is also used to talk to *Mir* during the rendezvous and docking. For high inclination missions, orbital dynamics and the crew timeline results in Surrey England being the most suitable location for the radio test. Twenty-one hours after launch, Doug Loughmiller, G0SYX/KO5I had an excellent pass that allowed him to talk to commander Ken Cameron, KB5AWP.

The shuttle launch occurred when a threat of a Federal government shutdown was imminent because of the budget impasse. As a result, only critical Federal services would be permitted to continue, and it was not certain until late in the shutdown process whether the shuttle mission would be considered critical. On November 14th at 10 am CST, all non-essential NASA activities were shut down. Fortunately, the shutdown did not affect the mission and SAREX activities continued unabated, and SAREX bulletins and STS-74 orbital elements were distributed through the normal channels.

On November 15th, *Atlantis* and *Mir* docked on time, when Ken Cameron gently flew the combined shuttle/docking module combination in to *Mir's* Krystall docking port. After docking, ICOM and Kenwood transceiver manuals were delivered to the *Mir* cosmonauts, along with food, water, and other supplies.

During the STS-74 mission, five scheduled SAREX school contacts were all accomplished on the first attempt with the astronauts answering 54 student questions. As a result, over 2,300 students at the five schools watched as their respective school made contact with the *Atlantis*.

The STS-74 mission also marked the debut of the most recent SAREX telebridge station which is located in Santa Rosa, California. The station was installed at the Santa Rosa Junior College by AMSAT and student volunteers. Over the past year and a half, students and volunteers at Santa Rosa raised \$30,000 in donations to construct the SAREX telebridge station and for its use as an educational outreach facility. The station is currently being managed by Tim Bosma, AB6FL. SAREX volunteer Steve Teegarden, WH6IC, was instrumental in setting up this station. The Santa Rosa team also received guidance and support from SAREX volunteer Dick Flagg, AH6NM, who manages our SAREX telebridge station in Hawaii.

During STS-74, I was lucky enough to work Bill McArthur, KC5ACR from the Phase 3D Integration Laboratory in Orlando, Florida. Meanwhile, Chris Hadfield, VA3OOG was certainly popular with his fellow Canadians. Hams as far as 68° North latitude in the Northwest Territories were able to successfully contact *Atlantis*.

On November 16th, the Canadian Broadcasting Corporation (CBC) Radio National News reported:

A ham-radio operator from Alberta is thrilled that he was able to contact the space shuttle Atlantis and talk to the Canadian astronaut, Chris Hadfield. Prime Minister Chretien was unable to get through to Hadfield. NASA was forced to cancel his call because of the budget stand-off which has shut down many U.S. government operations. But Scott Smith, VE6ITV, of Tiger Lily, Alberta, kept his transmitter warm and worked the wave-bands.

No word yet on whether or not the Canadian Prime Minister is considering getting his own Amateur Radio license just in case it becomes necessary on a future shuttle missions.

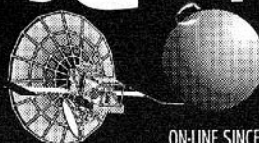
Chris Hadfield and Bill McArthur, KC5ACR were very active on random QSO passes over the United States. The crew kept the SAREX operations going until just before they were ready to return home. Bill was still making voice contacts on orbit 125 which less than seven hours prior to

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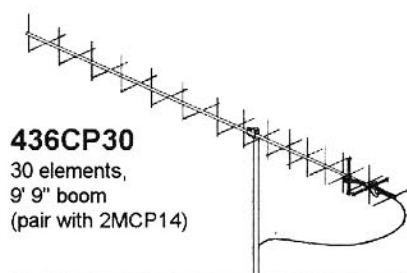
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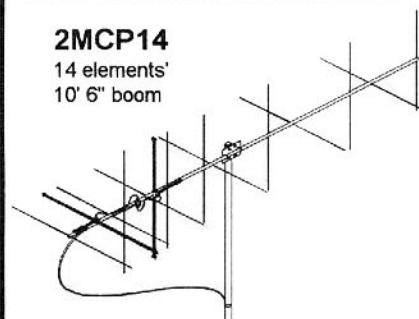
436CP42-U/G

42 elements,
18' 10" tapered boom
(pair with 2MCP22)



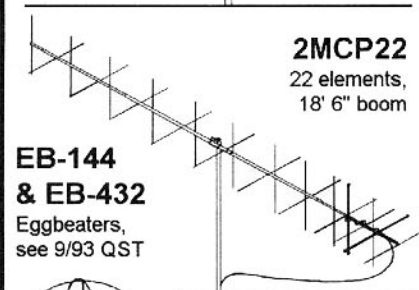
436CP30

30 elements,
9' 9" boom
(pair with 2MCP14)



2MCP14

14 elements'
10' 6" boom

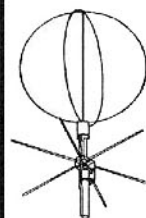


2MCP22

22 elements,
18' 6" boom

EB-144 & EB-432

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see 9/93 QST



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landing. The SAREX team estimates that the STS-74 crew made about 100 general voice contacts per day.

The STS-74 mission finished with a perfect landing at the Kennedy Space Center on November 20th, just as the government came off its shutdown furlough. The landing marked the end of the fourth successful SAREX flight for 1995 which is a new record for the number of SAREX missions within a calendar year. Within a couple of hours after landing the crew received their first QSL card, handed to commander Ken Cameron.

QSL cards and reports with STS-74 may be sent to *ARRL EAD, STS-74 QSL, 225 Main Street, Newington, CT 06111-1494, USA*. Please include the following information in your QSL or report: STS-74, date and UTC time, frequency and mode (FM voice). In addition, you must also include a SASE using a large, business-sized envelope (#10) if you wish to receive a STS-74 QSL card. The Greater Norwalk Amateur Radio Club in Norwalk, CT has volunteered to manage STS-74 QSL cards.

The Mir 20 crew is expected to return to Earth on February 29, 1996. The two crews plan to get together to present a UN flag to Boutros Boutros-Ghali the Secretary General of the United Nations. The flag was launched aboard a Russian Soyuz spacecraft and returned to Earth by the *Atlantis* and is one of the many examples of international cooperation during the joint mission.

Special thanks to Phil Chien KC4YER, Matt Bordleon KC5BTL, Frank Bauer KA3HDO, and Pat Kilroy WD8LAQ for information within this article. ■

Oscar-13 Mean Motion - Predicted and Actual Values

James R. Miller G3RUH g3ruh@amsat.org
Original 1995 Dec 11/Updated 1996 Apr 18

Editor's Note: With AO-13's re-entry only a few months away, Command Station Member James Miller, G3RUH has been performing a detailed aerodynamic and thermal study to explore what we can expect to happen and when. Changes to the orbital period are already apparent, as is a significant and growing rate of change of attitude. James' report "AO-13 Re-Entry Plans" will be featured in the July/August issue of The AMSAT Journal. The associated plot is available via Internet: <ftp://ftp.amsat.org/amsat/satinfo/ao13/mmplot.zip> (14k).

The most sensitive indicator of drag on any satellite can be found in the value of *mean motion*. As drag takes effect, mean motion increases, and the satellite appears earlier than if there were no drag. This effect is cumulative, and any earliness rapidly becomes very apparent.

The effect of atmospheric drag is now clearly noticeable in the NORAD Keplerian elements. Figure 1 depicts MMPLLOT.GIF (in mmplot.zip) compares the predicted value of Mean Motion with the NORAD values taken from all available 2-line element sets since 1996 Jan 03. From Figure 1 you can see that Mean motion has increased from 2.097275 to 2.097500 in just three months.

The predicted values of Mean Motion and other elements are based a model that includes a best estimate of the aerodynamic profile of the satellite. As time goes by, the agreement between predicted and actual Mean Motion will be used to improve this estimate, and so to improve re-entry predictions.

There are significant (2:1) variations in the atmosphere's density.

From 1995 Oct 05 until 1995 Dec 31 a drag coefficient of $C_d=0.75$ gave very good agreement between predictions and NORAD data, but the period 1995 Oct 05 to 1996 Mar 30 shows considerable divergence unless C_d is reduced to 0.4. Late 1995 is then a poorer fit.

Similarly, the fit from 1996 Jan 01 to 1996 Apr 17 gives a good fit on Apr 17 with $C_d = 0.375$, but the interim values agreed better with $C_d = 0.4$ as noted.

Further AO-13 decay information is available at: <ftp://ftp.amsat.org/amsat/satinfo/ao13/decaykep.zip> (13k).

The program used for predicting AO-13's future integrates the equations of motion. Forces modeled are Earth's gravity up to degree 8, zonal, tesseral and sectoral terms from the GEM10B model, Sun, Moon, atmospheric drag and solar radiation pressure. It is described and listed in: <ftp://ftp.amsat.org/amsat/articles/g3ruh/a114.zip> (107k).

My thanks to Dr. T. S. Kelso (tkelso@afit.af.mil), Adjunct Professor of Space Operations, Air Force Institute of Technology, for extracting hundreds of AO-13 Keplerian elements from the NORAD archives. ■

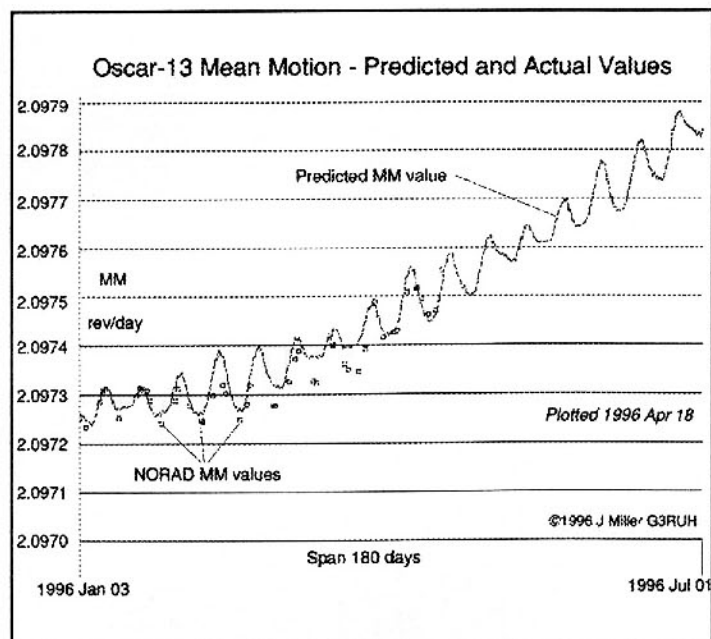


Figure 1. MMPLLOT.GIF

Donors To AMSAT-NA Phase 3D Funds Campaign

November 1, 1991 to February 19, 1996 - Part 2

Bob Carpenter, W3OTC, Phase 3D Fund Raising Campaign

Editor's Note: This is the second of a two-part series that identifies AMSAT-NA Phase 3D donors. Part 1 was published in the March/April issue of The AMSAT Journal and listed donors who have contributed over \$184.60. Please keep in mind there is still time and need to donate to Phase 3D construction and operations!

The AMSAT-NA Phase 3D Funds Campaign got underway in November 1991. Since that time over 2500 individuals and clubs have contributed over \$500,000. The Campaign established donation levels which could be achieved by yearly or lump-sum payments. Many have completed five-year pledges, although some joined the Campaign later and will complete their pledge in 1996. A final list will be published later.

In addition to the donors listed below, there were some notable large contributors. The Hoover Foundation provided over \$100,000 in matching funds. AMSAT-UK contributed over \$76,000. The American Radio Relay League conducted its own Phase 3D campaign on behalf of AMSAT-NA, providing over \$160,000 to match its donors, for a total of over \$320,000 in 1995. The 1993 the ARRL conducted a similar campaign and provided about \$200,000. The J. C. Downing Foundation donated \$15,000 and an anonymous foundation donated \$10,000.

Also not listed is the roughly \$45,000 that Phase 3D has collected in donations for the SATSKED, WiSP, and WINSAT tracking programs. These programs were donated for the benefit of Phase 3D by their respective authors: WA2N, ZL2TPO, and KA7LDN.

AMSAT and the Phase 3D project depend on people. We owe special thanks to those who have donated thousands of hours of their time and skills instead of money.

Donors are listed in decreasing order of total donation. Those with equal donations

are listed in inverse alphabetic order. Those who have notified AMSAT headquarters of a donation of \$36.92 or greater to the the 1996 ARRL Phase 3D campaign are marked with an asterisk.

Other Donors - total donation of at least \$50

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KD4UFC, KC5DQ, KC4YMB, KA8PTQ*, K4MEF, K3VRS, K3MFI, K1VYU, IW0RFK, I1BY, Richard H. Robertson, KC6EIJ, AB4NJ, AA9AW, K6GHZ, W0YPT, N0MTO, Don Sanford, Thomas May, WC9F, WB5CQK, W6QYY, W5RKN, N3CXP, N2GGQ, N0MQC, KE8YH, AA2DW, YV5EAL, JAAP CALJOUW, Daniel Lengrand, ZL2BAC, WB8ZTV, W7KJZ, W5BCB, ON6RL, N1SBB, N1HRK, KB8EMH, KB0DLR, XE1AC, WU5X, WB8WUP, WA6UCA, WA2GFH, W9HAD, W7LFX, W5IAV, W4CSV, W3LNA, W3HQX, W2HXF, W1ICW*, W1GYD, VO1OR, VE7VL, VE3BUP, SV3KH, N5IST, N4GQD, N2IIL, N2BOF, Iliya Jazic, KD7EW, KD6OCV, KC3UM, KB7WAU, KB7UZ*, KB5ZDV, KB4NY, KA9LNV, KA1EPF, K7BZ, K3DD5, K0OV,

HB9AQZ, Columbus Radio Club, KB0BVR, WN7B*, N4NR, KA4OQS, W7QLC, N3MS, YV5JDP, WZ7O, WD4O, WB5TUF, WA8AHV, WA0UQA, W6XS, W5RTW, W3YAE, W2IFR, W1YN, N9EP, N9AVG, N6WXN.

N0NAP, KE7NR, KD9CA, KD3UY, KB4ZB, KB4YML, KB1KO, KA0WTX, K8EIW, K6OYY, K5JHS, K1PDY, H.W. Lichte, AC4T, N8XCX, W4TZG, W3WOD, N1ATB, N0LEF, KQ4AV, K8TL, KB9E, KB7HED, WA3JWP, PY3RUY, EA6IC, W9JI, KA7TWQ, JH1AOY, WT3A, WD8OBL, WB9CER, WB4HYY, WA1MDD, W9IPO, W8IWA, W0RNL, VE3MDL, N5RRL, N5QJU, N4GT, N1KNC, N1IUS, KL7CQ, KK6QP, KH6FMT, KB7ZPJ, KB7LZR, KB2CST, KA9VPE, KA1IFX, K2VPR, F1DYD, VE7JNJ, VERONA, WB8TSL, N2MB, KM6SE, KB2OPQ, JEFF ZERR, N3IRY, KC6JAE, G3WGM, N5VGC, KD6VV, KD6TOE, Club Radioaficionados Guatemala, WB4VNT, WB4OBO, WB0SOK*, WA2SMF, W6OV, N9QIU, N8JTR, N1QXW, N1MGB, KB1PI, AD4YE, KC5TU*, KA9ITZ, VE2MPA, N4SKR, WA7HVB, WA6ILT, W5AE, W4BOC, W4AUZ, VK8AH, VE3LXK, VE3CBN, N7ZKL, N2WWD, KN4SM, KA2RVO*, K2TT, IK3ASM, AA1GI, VE3XR, K5RTP, WB2VVV, PJ2MI, K8DHA, KO3Z, W2YTO, N4QOT, XE1AAK, WS8G, WG6G, WG3E, WB7PZU, WB5IPM, WB2CIX, WA6HNC, WA2ELF, WA1TSS, WA0CTZ, W9LCA*, W9GUI, W9FRU, W4PID, W3TQ, W2WGL, W0FB, VK5APF, VK4CBD, TI2AEB, PJ2TR, NP2AV, NASA/JSC Radio Club, N9YTW, N8TEZ, N6XIB, N4USG, N3OBY, N3KS, N3CEV, N0UA, N0MII, LU7KY, LU1DUT, KQ4IN, KN6GD, KK5PO, KI6QE, KE4EKW, KD6IRE, KD4LTP, KD4HJ, KD4GKO, KC7GY, KC6TTU, KC5GLG, KC5GJ, KC3QP, KB6LE.

KB5VIU, KB3DU, KB0PRT, KA2OEE, K8YMI, K8UTY, K4WKI, K3JH, K1WW, K1CM/EI4CM, K0TLM, JA1EMX, HB9MQM, F6EPU, DL9MFN, Dennis Kelly, AA6HA, AA3IN, 9Y4NED, VE6XD, KF6EN*, WD4GYW,

WA3KNN, W6BBO, W4DVG, VE7GRP, N5AHD, KC4YMG, KC3MM, KB0IFZ, K6KKO, W6PYU, KD6DYS, KD4QEM, VE5NC, W9ODI, TR8BL, K3VDB, WU6H, WA7JMA, WA6FIG, W8MAO, NH6N, N8VYT, N7YPJ, N7PPA, N4IQ, KA2KDP, AE2N, W6IAQ, KA8RUB, N2SPI, KD4CKY, Tyler Amateur Radio Club, KB4ABE, ZL2ALP, W9VYD, N2ALA, K9APE, FIDQD, VE3TOK, PY6ASV, EA1QJ, WQ5N, WD5DGT, WD0BQM, WB9OEP, WB0IIS, WA2YRA, W5RCJ, W5CTL, W4WJ, W0WGZ, Roger Jolly, Richard Murabayashi, N05O, N6QQ, N5EV, N4IIL, N3JON, N2ONK, KG7AY, KE2MF, KD4EMS, KD3CN, KC4YET, KB4ZJ, KB2EZV, KB1QV, KA8JN, KA3HDO, KA1SAW, KA0OGU, K4YYL, K4VB, James C. McLarnan, MD, 9M2OK, WL7AML, WE1U, WB9OLI, W9OER, W2GTX, W2/G6XAW, NN7K, N8NPA, N6HNY, N0OQU, KB4AG, WD4MKU, VE3AC, N6EJW, KI5NT, David Chistoni, WC1B*, WB7PMS, W3TFA, N1GWO*, JA9KRO, WA2VUJ, ZL1TTX, ZF1RC, WV6Z, WU8H*.

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KD9EJ, KD6UO, KD4KGZ, KD4FTY, KD4CEE, KD1WA, KC5FEY, KC4VXU, KC4BQX, KC0TR, KC0BF, KB7QQO, KB2PAY, KB0MPB, KB0CY, KA5WLW, KA3JAW, KA3BCO, KA2HDD, KA1JMF, KA1DF, K9PUR, K9EN, K8NJA, K8CYV*, K6DRN*, K6CIL, K5EVI, K4NTD, K4EMN, K4BQH, K3SHK, K3MKZ, K3KKA, K3HPS, K2JWD, K1SXA, K0PHD, JH3BJN, JA1FRZ, IW1DZU.

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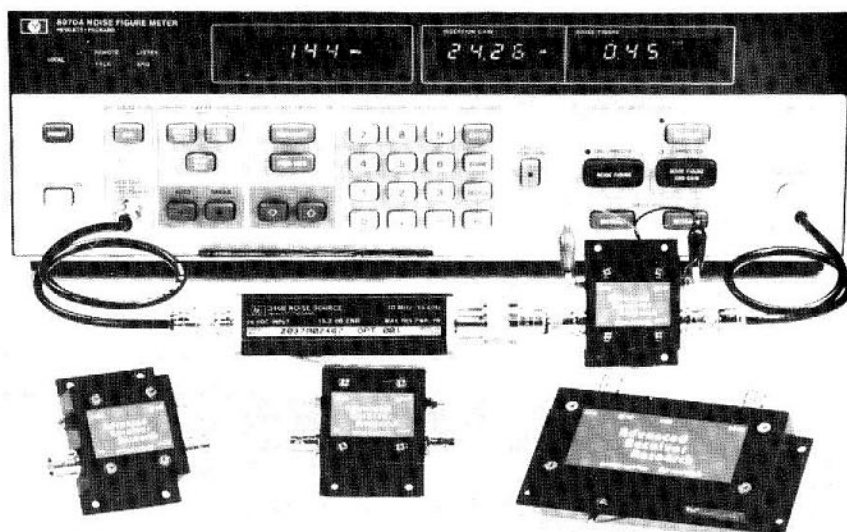
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P220VDG	220-225	< 0.5	20	+12	GaAsFET	\$79.95
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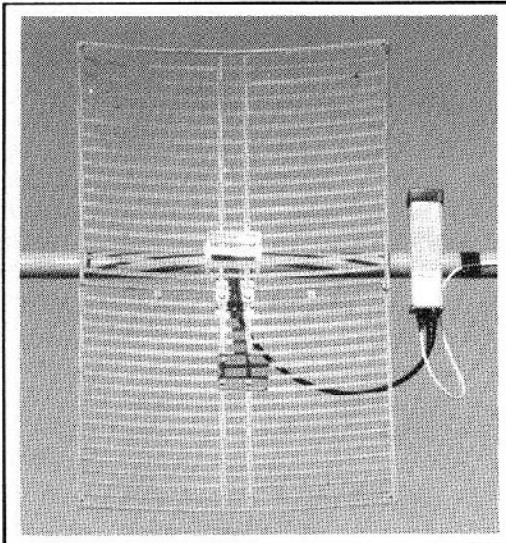
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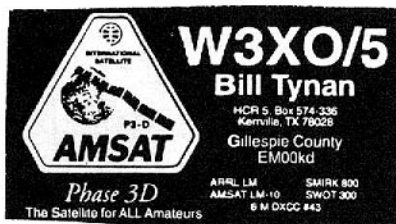
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W2MSJ*, W2IOV, W2GJS, W2DEG, W1QJR, W0TUP, W0DQM, VK2IE, VE7MM, VE3PYG, VE3ETB, VE2GAG, VA3RAE, Ronald Burkhart, Rodger Pape, PA3FDM, NL7FQ, NK5B, N9YPO, N9MUR, N9MEZ, N9IBD, N8TRM, N8PVV, N8MBZ, N8LPB, N8LM, N8IWJ, N7OLS, N7NXV, N6QU, N6MN, N5OLF, N5KBG, N4CSF, N3NBT*,

HK3EPV, F2BJ, CX9BT, VE3BWG, KC2IV, VE3IHI, WD8QCN, WD4IUG, WB9KCC, WB9AOU, WB8IMY, WB7OQX, WB7ATT, WB7ASR, WB4GFN, WA7ZFW, WA6ZVP,

Phase 3D QSLs

Show your support for Phase 3D every time you QSL!



Front

This confirms a QSO with _____
on _____ at _____ Z
_____, 19 _____.
Your _____ signals were _____
Rig _____ W to _____
Ant. _____
Thanks for the contact and 73.

Back

Cards are postcard size with red background and gold lettering. for name & call. Other lettering in white. Insert is light blue with dark blue lettering & AMSAT logo is red. Spacecraft is gold with purple solar panels. Earth is various shades of blue & white.

Please print your name & call as you want them to appear on the right front of your QSLs.

Name _____ Call _____ Address _____
City _____ State/Province _____
ZIP/Postal Code _____ Country _____ County (if desired) _____
Other information, such as AMSAT #, ARRL, WAS, DXCC etc. (Six items only)
1,000 cards \$150, plus \$5 US, \$12 Canada, \$20 other (Surface). Orders will be processed in batches of eight.
____ Check, VISA/MC # _____ Exp. _____
Daytime Phone: (____) _____ Signature _____

WA6NZI, WA6ASI, WA5YKD, N5ZEV, N5HEU, N4XEO, N4WYK, K1YPP, K1RB, Joseph Neal, Jr, JE9PEL,
 WA4BBU, WA2TLI, WA2EGT, N3GDE, N3GBS, N3FIP, N2PPH, I1CAW, George Thomas, EA2AFF,
 WA2DTN, WA1WNB, WA1WLU, N2PEV, N1NQH, N1ILV, N1CRK, Charles Jones, AE6S, AD7L, AD4SB,
 WA1FXK, WA1ENO, WA0ALH, N0YFL, N0AW, Michael Babb, KX7L, AC0E, AA9AD, AA7JM, AA6UF,
 W9YGI, W9MRE, W9FBC, W8LHV, K15WF, KF4BY, KE4HEF, KE4GRV, VK2DVW, ZL3TPD, WV7K, WA6WZO,
 W7ITV, W4LCL, W3VVP, W3EP, KD4WCH, KD4QLF, KD4OZI, WA5NIJ, W1CMR, Terrence G. Kolton,
 W0KUX, VU2RMS, VE7TIN, VE6BJW, KD4OOF, KD4MZL, KD3OJ, KC7BGP, N9DHM, N8ENJ, N7SGA, N3QWE,
 VE4AP, VE3ONV, VE3HOL, TRW KC5IPB, KC4EJV, KB9QV, KB6KEN, NILES, N1JIJ, KX3Z, KN6BY, KF8PH,
 Employees Charity, Skyware, OD5RI, KB5UAA, KB3MF, KB3ALG, KB2CE, KD4UKR, KB2NED, KA8SYX, K9RY,
 NN8O, NI8Z, NI1X, NH6QT, N9MLM, KB0OBT, KA8CFC, KA6NBA, K2KXS, DL1TV, CU2GK, AA4BC,
 N9LWQ, N8ZMD, N8GDE, N8AZI, KA2WQA, KA2FPZ, K9PIG, K6RMO, 7J1ALV, WB7EWK ■
 N7WXE, N7WMV, N7WKS, N7MTZ, K5ERP, K5AUW, K3GR, K3FXB,

Satellite Orbital Elements

Ray Hoad

Satellite	AO-10	UO-11	RS-10/11	AO-13	FO-20	RS-12/13	ARSENE
Catalog Number	14129	14781	18129	19216	20480	21089	22654
Epoch Time	96108.73023	96116.01973	96116.1196	96115.32427	96116.13188	96115.81106	96114.8845
Element Set	415	891	207	190	881	889	361
Inclination	26.28	97.7973	82.9269	57.3084	99.0327	82.9213	3.1178
RA of Node	213.9904	109.1184	187.7596	121.2661	151.0595	228.9116	74.6777
Eccentricity	0.5996717	0.0010537	0.0011029	0.740513	0.0539916	0.0030544	0.2874376
Arg of Perigee	7.9297	261.6262	311.1517	37.5919	244.754	23.9509	235.0563
Mean Anomaly	358.3577	98.375	48.8687	356.0294	109.6673	336.3064	94.5749
Mean Motion	2.05879049	14.69446213	13.72365076	2.09759237	12.8323336	13.74068454	1.42203256
Decay Rate	-0.00000074	0.00000119	0.00000103	0.00000744	0.00000028	0.00000011	-0.00000116
Epoch Rev	9659	64984	44289	6020	29108	26170	1082
Satellite	RS-15	UO-14	AO-16	DO-17	WO-18	LO-19	UO-22
Catalog Number	23439	20437	20439	20440	20441	20442	21575
Epoch Time	96116.05969	96116.14961	96116.10943	96116.13694	96116.12566	96116.12549	96116.20233
Element Set	140	184	988	996	987	995	682
Inclination	64.815	98.5444	98.5592	98.5615	98.5614	98.561	98.355
RA of Node	108.9976	200.1529	202.2477	202.8824	202.8179	203.2865	184.1513
Eccentricity	0.0162842	0.0012083	0.0011815	0.0012217	0.0012745	0.0012923	0.000877
Arg of Perigee	208.5428	1.9944	3.4784	2.261	2.2195	1.5597	62.1853
Mean Anomaly	150.6502	358.1286	356.646	357.8626	357.9044	358.5627	298.0216
Mean Motion	11.27524623	14.29917847	14.29972853	14.3011435	14.30084706	14.30192123	14.37020808
Decay Rate	-0.00000039	0.00000001	0.00000019	0.00000009	0.00000053	0.00000017	0.00000031
Epoch Rev	5479	32647	32648	32651	32651	32653	25045
Satellite	KO-23	AO-27	IO-26	KO-25	MIR	HUBBLE	GRO
Catalog Number	22077	22825	22826	22828	16609	20580	21225
Epoch Time	96115.99268	96116.16388	96116.16422	96116.22792	96116.16776	96116.17289	96115.01975
Element Set	574	491	477	446	516	820	368
Inclination	66.08	98.5823	98.5862	98.5795	51.6488	28.4688	28.4604
RA of Node	300.8366	192.6619	192.8205	192.9356	29.5933	199.3159	202.4073
Eccentricity	0.0010847	0.0009634	0.0010614	0.0011301	0.0004052	0.0005931	0.0002383
Arg of Perigee	312.0011	28.6394	26.5694	14.0382	236.4643	341.9073	314.1274
Mean Anomaly	48.0081	331.5314	333.6016	346.1101	123.5961	18.1306	45.9129
Mean Motion	12.86296693	14.276932	14.27801738	14.2813833	15.5790522	14.9104821	15.4391123
Decay Rate	-0.00000037	0.00000023	0.00000034	0.00000037	0.000035	0.0000044	0.00002154
Epoch Rev	17396	13442	13443	10255	58174	13066	16155

AMSAT Journal Telemetry

W3XO Named Dayton HamVention 1996 Amateur of the Year

William A. (Bill) Tynan, W3XO, has championed the cause of VHF/UHF enthusiasts, worldwide. He had been contributing editor for *QST* Magazine's "World above 50 MHz" column for eighteen years, providing a medium to nurture new communication techniques, encourage DX performance and improve contesting rules on the VHF/UHF bands. He pioneered the establishment of the Radio Amateur Satellite Corporation (AMSAT). From the founding days of the first OSCAR-6 launch to his present post as President of AMSAT, Bill has sacrificed much of his personal time, talent and resources to the promotion and development of the amateur satellite program. His vision continues with the advent of the Phase 3D project, scheduled for launch in December, ushering in an entirely new dimension of amateur radio operation. *Congratulations W3XO!*

AO-13 Schedule

The re-orientation to attitude ALON/ALAT 180/0 is complete, and the new transponder schedule is in place:

AO-13 TRANSPONDER SCHEDULE March 30 - June 17, 1996

- Mode-B : MA 0 to MA 70
- Mode-BS : MA 70 to MA 120
- Mode-S : MA 120 to MA 122 - S beacon only
- Mode-S : MA 122 to MA 140 - S transponder; B trsp. is OFF
- Mode-BS : MA 140 to MA 180 - Alon/Alat 180/0
- Mode-B : MA 180 to MA 256
Move to attitude 220/0, Jun 17
- Omnis : MA 230 to MA 25

Note that the higher powered engineering beacon 145.985 MHz is ON for two periods: MA 0 - 25 and MA 90-100.

PROVISIONAL AO-13 TRANSPONDER SCHEDULE

Schedule: June 17 - September 2, 1996

- Mode-B : MA 0 to MA 140
- Mode-BS : MA 140 to MA 240

- Mode-B : MA 240 to MA 256
Alon/Alat 220/0
- Omnis : MA 250 to MA 140
Move to attitude 180/0, Sep02

1996 AMSAT Annual Meeting and Space Symposium Call For Papers

Dave Burnett, WD8KRV

The 1996 AMSAT Annual Meeting and Space Symposium will be held on November 8-10, 1996 at the Holiday Inn, City Center in Tucson, Arizona. This is the first call to authors who wish to submit papers for this event. As always, the scope of the papers should be on topics of interest to the amateur satellite service.

Topics may include, but are certainly not limited to:

- The Life and Times of AO-13
- Building a Phase 3D Ground Station
- Phase 3D Construction Topics
- DSP-93 Integration
- AMSAT Field Operations
- What's Next for AMSAT After Phase 3D?

We also would like to solicit topics from the AMSAT community. In other words, what topics would *you* like to see presented at this year's Annual Meeting?

Abstracts from authors should be submitted by June 15, 1996. Final versions of all papers should be received by August 15, 1996. Proceeding's of the symposium will be printed and available at and after the meeting.

Submissions and inquiries should be made to Dave Burnett, WD8KRV:

G. D. Burnett
4809 E. Pima #223
Tucson, AZ 85712
Internet: wd8krv@amsat.org

Information about the Annual Meeting home page will be included in a future announcement. *73 and we look forward to seeing you in Tucson!*

Apogee View (continued from page 3)

We feel that we have a legal obligation to send all members, ballots for the Board election. Therefore, even those who have indicated that they are no longer interested in amateur satellites, will continue to receive ballots. For those who do not want to receive any further mail from us, the letter provided the option of resigning from AMSAT membership altogether.

I hope that this has served to clear up any misunderstandings that might have been created by the letter. For those, I apologize.

Phase 3D Launch Update

This column in the last issue of the Journal addressed the status of the Phase 3D launch. The basic information is largely still correct, but a few things have happened since the editorial was written which I want to pass on to our membership. INTEL SAT no longer intends to launch their 709 spacecraft on Ariane 502 and are making arrangements for its launch on an Ariane 4 sometime this summer. This could mean that Phase 3D might yet be launched on Ariane 502. However, it is understood that negotiations are underway which might result in another satellite going on 502 which would have the same effect as the INTEL SAT 709, precluding our ride on that mission. However, nothing has been said to change the other statement made regarding the commitment Karl Meinzer, Phase 3D's Project Leader, has with the European Space Agency; namely that Phase 3D will be launched, if not on Ariane 502, then on an Ariane 4 mission by mid-1997. ■

Mars Relay Flight Test Homepage

John Callas, NASA Jet Propulsion Laboratory informs us that the Mars Relay Test Homepage has been revised at <http://msg-www.jpl.nasa.gov/> See the March/April issue of *The AMSAT Journal* for more details.

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- One-touch Doppler Shift Adjustment
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